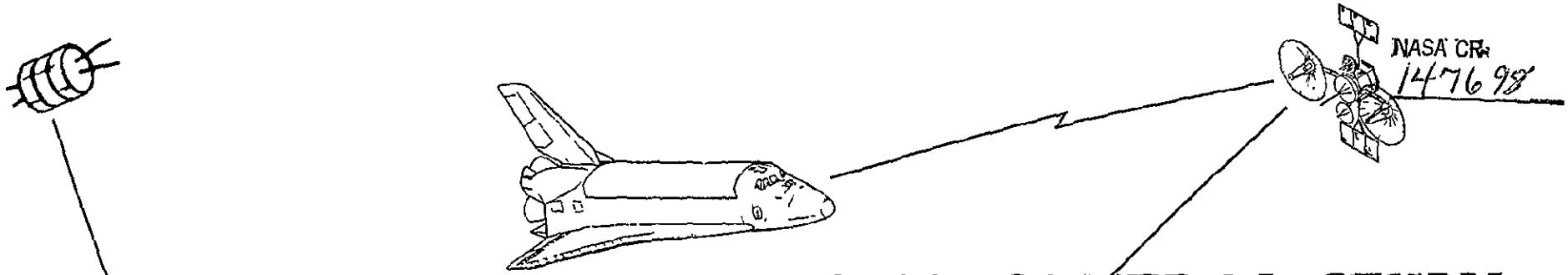


STS PAYLOADS MISSION CONTROL STUDY

(NASA-CR-147698) STS PAYLOADS MISSION CONTROL STUDY Final Progress Report (TRW Systems Group) 124 p HC $5.50 CSCL 22B
N76-24334
Unclas
G3/16 41801

Final Progress Review

CONTRACT NAS 9-14484

PREPARED FOR

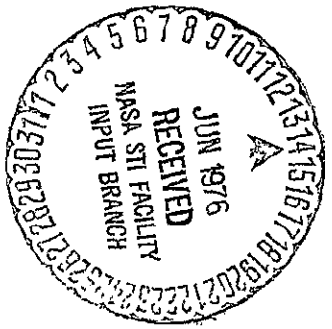
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

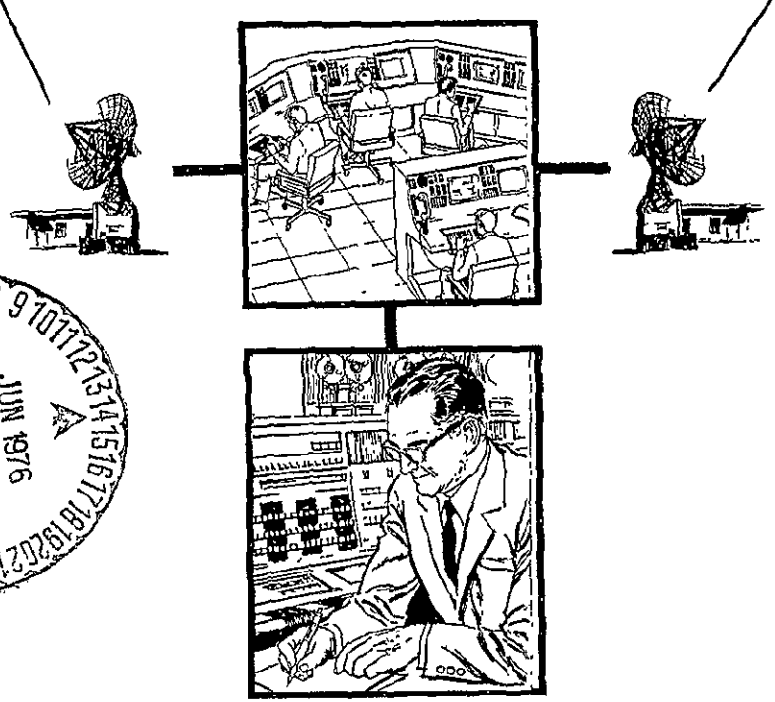
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

PRESENTED TO

STEERING GROUP FOR STS PAYLOAD OPERATIONS CONCEPT STUDIES AT AMES RESEARCH CENTER

October 1975





TRW SYSTEMS GROUP

STS PAYLOADS MISSION CONTROL STUDY

FINAL PROGRESS REPORT

CONTRACT NAS 9-14484

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
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STEERING GROUP FOR STS PAYLOAD
OPERATIONS CONCEPT STUDIES
AT AMES RESEARCH CENTER

22-23 OCTOBER 1975

TRW
SYSTEMS GROUP

STS PAYLOADS MISSION CONTROL STUDY

STUDY OBJECTIVES

These are the basic objectives of the Study. They have remained unchanged. In the process of meeting these Study objectives, information was developed for use by NASA in arriving at STS Payload flight control activity allocations to NASA Centers. Seven basic Study tasks are described in the following pages which produce documentation to meet these objectives, i.e.: flight control functions, NASA flight control capabilities, function allocations, operational communications and information processing plans, alternative system concepts for STS Payload flight control support and estimated additional resources for selected system concept(s).

STS PAYLOADS MISSION CONTROL STUDY

STUDY OBJECTIVES

- IDENTIFY FLIGHT CONTROL GROUND FUNCTIONS FOR REPRESENTATIVE STS PAYLOADS (REQUIREMENTS) AND NASA CAPABILITIES TO SUPPORT THEM.
- DETERMINE FEASIBLE, COST EFFECTIVE SYSTEM CONFIGURATION OPTIONS FOR FLIGHT CONTROL OF STS PAYLOADS.
- ESTIMATE ADDITIONAL NASA RESOURCES REQUIRED, IF ANY, TO IMPLEMENT NASA-SELECTED OPTION(S).

STUDY TASKS

The Study consists of the seven basic tasks listed. The Ancillary Task, "Identification of User Enhancement Factors", is included with Task f. Each of these tasks typically consists of three or four subtasks. For example, Task c consists of Subtask c.1, "Establish Categories of Capabilities Information Needed", followed by Subtask c.2, "Conduct Interviews and Follow-up with Key Personnel". Finally, the information obtained is documented in a "NASA Capabilities Document" (separate volume for each NASA Center), Subtask c.3, and coordinated with contributors prior to publication.

These tasks may be considered as being accomplished in three major phases of activity. Task a, b and c constitute the first phase, the Data Collection Phase. The second phase, primarily a "Systems Engineering and Analysis" type phase consists of Tasks d, e and f. It begins with the allocation of flight control ground functions between the STS Operator and Payload Operator while operational information flow and processing plans are being developed, and culminates in the identification of viable system concept options for allocation of payload flight control activities among NASA Centers. In the last phase, Task g, a methodology is established for estimating resource requirements for system concept option(s) selected by NASA and actual estimates made of any additional resources required to carry out the chosen option(s).

Task b objectives have been enhanced to include identification of candidate facility utilization concepts to be examined in more detail later under Task f. Also, the establishing of operational interfaces, formerly part of Task d, has been shifted to Task e, and analysis of Task d results has been included in Task f.

STUDY TASKS

a. IDENTIFY FLIGHT CONTROL FUNCTIONS AND ALLOCATE ONBOARD/GROUND.

b. IDENTIFY GENERIC TYPES AND LOCATIONS OF PARTIES INVOLVED AND CANDIDATE FACILITY UTILIZATION CONCEPTS.

c. ESTABLISH PRESENT/PLANNED NASA-WIDE FACILITIES CAPABILITIES.

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d. ALLOCATE FUNCTIONS BETWEEN STS OPERATOR AND PAYLOAD OPERATOR.

e. ESTABLISH OPERATIONAL INTERFACES, INFORMATION FLOW AND DATA PROCESSING PLANS.

f. DEFINE ALTERNATIVE SYSTEM CONCEPTS.

---

g. ESTABLISH RESOURCES METHODOLOGY AND ESTIMATE ADDITIONAL RESOURCES FOR SELECTED SYSTEM CONCEPT(S).

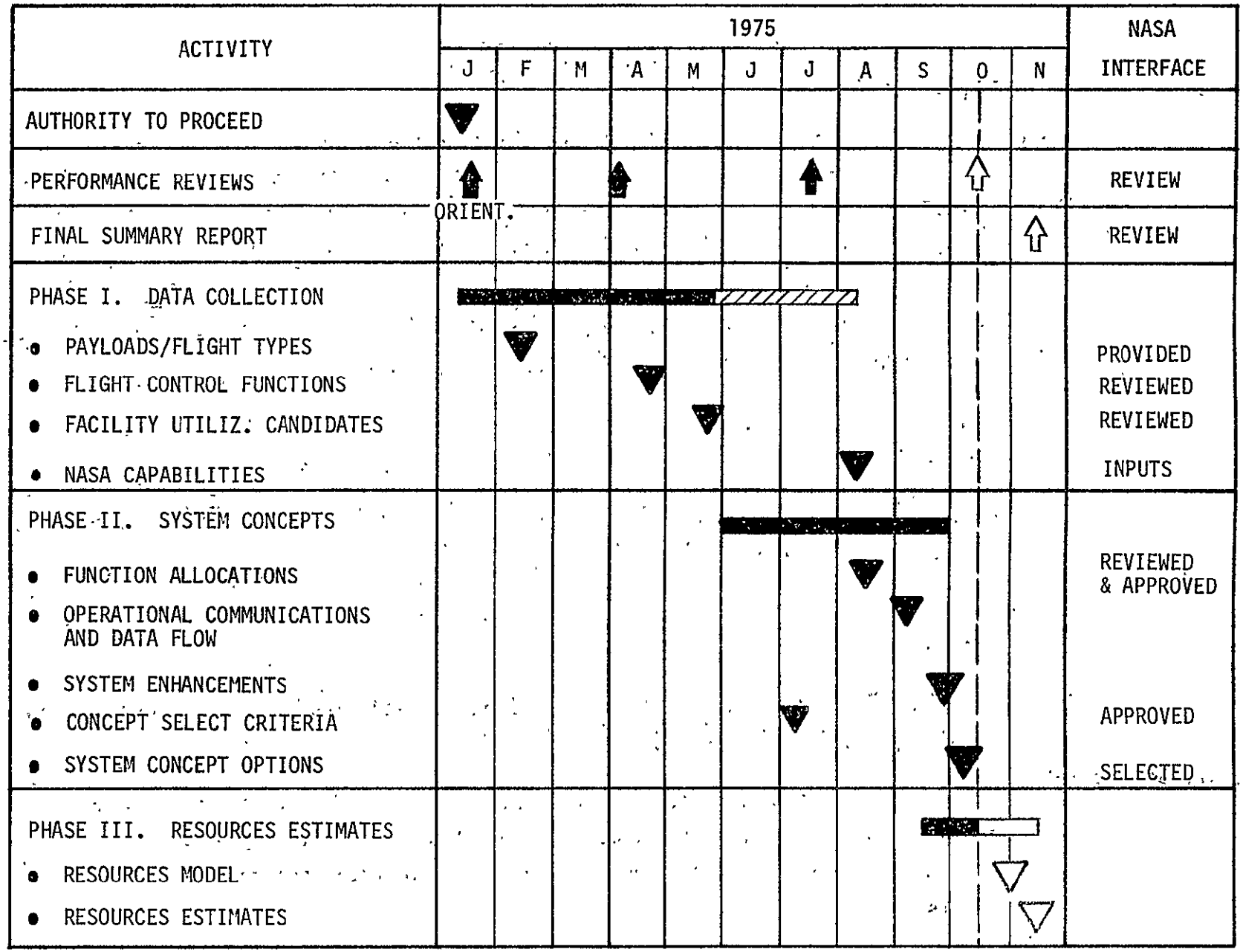
STUDY SCHEDULE

The Study consists of the three major activity phases as shown on the schedule, culminating in completion of the Final Report after 10 months. The Final Report consists of 15 volumes published incrementally throughout the Study, including the Executive Summary Report (Volume I) at the end of the Study, plus a separately bound document for each Task and a separately bound document for the facility capabilities at each NASA Center visited under Task c. Nine months of this 10-month Study are completed. Phase I, the Data Collection Phase, was extended an additional two months to allow for including extensive unforeseen additional inputs to the Center Capabilities Documents provided after initial contacts and after release of Preliminary Draft versions of the documents.

The Phase II activities leading to selection of a preferred system concept have been completed. Ground function allocations and operational communications and data flow information have been documented as Task d and e reports, respectively. In Task f, the first step was to define System Concept selection criteria and coordinate these with the COR. Alternative system concepts were then developed for assessment against these criteria. NASA has selected the preferred concept for quantitative assessment by the Study Team of additional resources required. The last Task, g, is in-process and will be documented in time for delivery with the Summary Report.

Each of the four Study Reviews shown on the schedule has been followed by a review with the NASA Steering Committee for STS Payload Operations Concept Studies.

STUDY SCHEDULE



STUDY GUIDELINES

The General Study Guidelines have remained unchanged with exception of the Flight Traffic Model, Guideline 19, which was updated by the COR as of 4 June 1975. Detailed statement of each general guideline follows:

1. The STS, consisting of the Shuttle, IUS/TUG and Spacelab support systems, with flight control from MCC/JSC, provides a service to "customers". ["Customers" here are all NASA Centers and selected non-NASA/non-DOD payloads that utilize NASA Centers for flight operations. (DOD payloads are not included in this study.)]

2. The main thrust of this study effort will address STS payload programs during the operational STS phase.

3. The existing NASA capabilities, resources and modus operandi will be used as points of departure in performing this study.

4. For automated payloads, flight control capability will be concentrated on the ground to the maximum extent.

5. Flight support shall be provided in a manner which satisfies the requirements at minimum overall expenditure of resources.

6. Flight support must be responsive to onboard assistance, for problem resolution and activity planning, but may be "on-call" rather than instantly responsive. "On-call" means having expertise and systems available, but not dedicated to flight support.

STUDY GUIDELINES

1. STS PROVIDES SERVICE TO "CUSTOMERS"

2. STUDY ADDRESSES STS PAYLOADS DURING OPERATIONAL STS PHASE

3. EXISTING NASA CAPABILITIES POINT OF DEPARTURE FOR THIS STUDY

4. GROUND CAPABILITY PRIMARILY CONSIDERED FOR AUTO PAYLOADS

5. PROVIDE FLIGHT SUPPORT WITH MINIMUM EXPENDITURE OF RESOURCES

6. FLIGHT SUPPORT TO PROVIDE ONBOARD AID "ON CALL" INSTEAD OF INSTANTLY RESPONSIVE.

STUDY GUIDELINES (CONTINUED)

7. Flight support shall be interactive, i.e., able to effect mission changes which maximize the mission value.

8. Payload operations will be performed by a payload organization or its agent within safety limits established by the STS Operator.

9. MCC/JSC will provide "flight support" for all NASA missions during prelaunch, ascent, reentry and landing. ("Flight support" here includes:
   - GO/NO-GO for launch
   - Trajectory, Event, Systems, Crew Status
   - Landing site readiness.)

10. For on-orbit operations during periods when STS has an operational interface with the payload, "flight support" will be jointly provided by MCC/JSC and the responsible Payload Operations Center. ["Flight support" here includes all functions (tasks) done in support of the on-orbit operations.]

11. For on-orbit operations during periods when the STS has no operational interface with the payload, "flight support" will be provided by the responsible Payload Operations Center or Agent designated by the responsible payload project office.

12. Payload organizations will utilize NASA Control Center host facilities for payload operations or establish their own Payload Operations Centers where economically justified.

STUDY GUIDELINES (CONTINUED)

7. FLIGHT SUPPORT IS INTERACTIVE TO MAXIMIZE MISSION RETURNS

8. PAYLOAD OPERATIONS SAFETY LIMITS UNDER COGNIZANCE OF STS OPERATOR

9. MCC GIVES FLIGHT SUPPORT DURING PRELAUNCH, ASCENT, REENTRY, AND LANDING

10. RESPONSIBILITY OF JOINT OPERATION OF STS AND PAYLOAD SHARED BY MCC AND THE POC

11. POC FULL RESPONSIBILITY FOR ITS PAYLOAD DURING FREE-FLIGHT

12. USERS UTILIZE NASA HOST FACILITIES OR ESTABLISH OWN POC

STUDY GUIDELINES (CONTINUED)

13. Major NASA Control Centers shall provide host facilities for customers, or provide appropriate operational interfaces with customers' remote location with respect to the Control Center, if feasible.

14. Required voice, data, command and tracking channels will be provided to all operations areas, but coordinated by MCC/JSC so long as STS has an operational interface.

15. Automation (computerized tools) should be employed by POC's if needed to meet flight requirements or if consistent with reducing operations costs.

16. Detailed "flight planning" for payloads is responsibility of the payload developer and the Payload Operations Center. Detailed flight planning for the Shuttle and integration of the flight plan definition for STS and STS payloads operations is the responsibility of JSC. ["Flight planning" is the generation of detailed procedures and timelines for nominal and contingency execution of flight activities.]

17. A semi-automated "flight data base" shall be assumed. The "flight data base" need not be in one location so long as means for adequate transfer and interfacing of information between operations centers is provided.
["Flight data base" is the reservoir of all data needed to plan or execute a flight, including system specification values, models, operating constraints, schedules, etc.]

18. Simplicity of interfaces during launch/landing and during flight among user, developer and operator, and ease of total STS/STS payload ground system verification shall be considered as criteria in assessing interfaces and costs.

19. The study will use the Flight Traffic Model provided by the COR on 4 June 1975.

STUDY GUIDELINES (CONTINUED)

13. NASA CONTROL CENTERS PROVIDE HOST FACILITIES OR OPERATIONAL INTERFACES WITH CUSTOMERS.

14. DURING STS/PAYLOAD OPERATION, VOICE, DATA, COMMAND & TRACKING CHANNELS COORDINATED BY MCC/JSC.

15. AUTOMATION IN POC IS DESIRABLE TO REDUCE COSTS.

16. PAYLOAD "FLIGHT PLANNING" BY PAYLOAD ORGANIZATION - STS/PAYLOAD INTEGRATED FLIGHT PLANNING BY JSC.

17. DISBURSED SEMI-AUTOMATIC "FLIGHT DATA BASE" ASSUME.

18. INTERFACE SIMPLICITY AMONG USER, DEVELOPER, AND OPERATOR AND EASE OF SYSTEM VERIFICATION IS CRITERIA.

19. WILL USE UPDATED TRAFFIC MODEL PROVIDED BY THE COR, 4 JUNE 1975.

TASK a
FLIGHT CONTROL GROUND FUNCTIONS

The objective of Task a was to identify flight control functions for given STS Payloads and Flight Types and allocate those functions between onboard and ground as a basis for further allocation of the ground functions between STS Operator and Payload Operator in Task d.

In order to complete this Task a objective, the first step was to identify and document payloads and flight types to be addressed by the Study Team. These were established by NASA and supplied via the COR to the Study Team along with current Flight Traffic Model for inclusion in Study documentation and analysis.

The Study Team then described characteristics of the payloads pertinent to flight control such as flight description, inflight handling - deployment/retrieval/servicing, potential STS interface, potential hazards such as in-flight contamination,and where known, experiment characteristics and Center assignment(s) for operations.

The major challenge in Task a was to identify flight control functions, such as verify ephemeris, monitor payload systems, compute consumables remaining, etc., that must be performed for each cargo flight type and applicable flight phase.

Finally, these flight control functions were allocated to Onboard (O), Ground (G), or Both Onboard and Ground (B), in Task a as a prelude to the special allocation of the "Ground" functions to STS Operator or Payload Operation or some combination of STS Operator/Payload Operator in Task d.

TASK a
FLIGHT CONTROL GROUND FUNCTIONS

OBJECTIVE: IDENTIFY FLIGHT CONTROL GROUND FUNCTIONS FOR GIVEN STS PAYLOAD FLIGHT TYPES AND ALLOCATE ONBOARD/GROUND.

SUMMARY OF TASK RESULTS:

- REPRESENTATIVE PAYLOAD FLIGHT TYPES WHICH WERE ADDRESSED BY THE STUDY WERE ESTABLISHED BY NASA AND DOCUMENTED BY STUDY TEAM.
- DESCRIPTIONS AND CHARACTERISTICS OF SELECTED PAYLOADS PERTINENT TO FLIGHT CONTROL DOCUMENTED.
- FLIGHT CONTROL FUNCTIONS FOR EACH PAYLOAD IDENTIFIED AND DOCUMENTED BY APPLICABLE FLIGHT PHASES.
- FLIGHT CONTROL FUNCTIONS ALLOCATED (1) ONBOARD, (2) GROUND OR (3) BOTH ONBOARD AND GROUND.

TASK b
TYPES AND LOCATIONS OF PARTIES INVOLVED

The main objectives of Task b were to characterize and describe the NASA Payload Development Centers as to their experience in and readiness or suitability for involvement in payload flight control operations, and to evaluate candidate facility utilization concepts for assignment of payload flight control roles.

Seven NASA Centers were visited and their characteristics for payload flight control documented with respect to the 14 flight types and 21 individual payloads under study.

With these NASA Center characteristics for payload flight control fresh in mind, three preliminary facility utilization concepts were defined and assessed based on appropriate involvement of the applicable Centers, in three payload flight type categories — automated earth orbit, planetary and spacelab. The three candidate concepts assessed as a precursor to Task f were: (1) complete centralization — one NASA Center for each flight type category, (2) partial decentralization, i.e., two or three NASA Centers per flight type category, and (3) complete decentralization, each Center responsible for flight control of its own payloads.

The concept assessment technique included both qualitative and quantitative techniques and flight traffic impact assessment. All techniques applied were useful as a basis for the criteria and approaches finally used in Task f.

TASK b
TYPES AND LOCATIONS OF PARTIES INVOLVED

OBJECTIVE: CHARACTERIZE NASA PAYLOAD DEVELOPMENT CENTERS FOR FLIGHT CONTROL OPERATIONS AND EVALUATE CANDIDATE FACILITY UTILIZATION CONCEPTS.

SUMMARY OF TASK RESULTS:

- DETERMINED NASA CENTERS' INVOLVEMENT IN PAYLOAD DEVELOPMENT AND MISSION OPERATIONS AND DOCUMENTED FINDINGS BY CENTER AND FLIGHT TYPE.
- IDENTIFIED PRELIMINARY FACILITY UTILIZATION CONCEPTS FOR PAYLOAD FLIGHT CONTROL (RANGING FROM CENTRALIZED TO DECENTRALIZED) AS PRECURSOR TO TASK f.
- ESTABLISHED AND APPLIED PRELIMINARY APPROACH TO ASSESSMENT OF ALTERNATIVE CONCEPTS. DEVELOPED TECHNIQUES APPLICABLE IN TASK f.

TASK c
PRESENT/PLANNED NASA-WIDE CAPABILITIES

The objective of Task c was to define each NASA Center's present and planned capabilities for flight control of STS payloads at the system level.

The Study Team first established guidelines and agendas for data collection and communicated these to NASA Center contacts provided at each Center by the COR. Guidelines included such information as level of detail (system level), extent of equipment identification (mainly functional), and guideline for "planned" capabilities (must be in approval cycle). These guidelines, along with functional categories for Data Collection and summary of results from the seven Centers visited are summarized in a Task c general document.

The seven Centers visited are as shown on the chart. Facilities/capabilities have been documented separately for each Center but in consistent format. The seven functional categories of information shown provided the consistent outline for the appendices and were carefully selected to provide information needed in Tasks e and f. These functional categories are defined in the General Task c document.

TASK c
PRESENT/PLANNED NASA-WIDE CAPABILITIES

OBJECTIVE: EVALUATE AND DOCUMENT NASA-WIDE PRESENT AND PLANNED FACILITIES/ CAPABILITIES FOR FLIGHT CONTROL OF STS PAYLOADS AT SYSTEM LEVEL.

SUMMARY OF TASK RESULTS:

- GUIDELINES FOR DATA COLLECTION AND ASSESSMENT ESTABLISHED.
- SEVEN NASA CENTERS VISITED AND DATA ON THEIR CAPABILITIES DOCUMENTED

APPENDIX A - ARC	APPENDIX D - JSC
APPENDIX B - GSFC	APPENDIX E - KSC
APPENDIX C - JPL	APPENDIX F - LaRC

APPENDIX G - MSFC

- GENERAL DOCUMENT DEFINES GUIDELINES, FUNCTIONAL CATEGORIES FOR DATA COLLECTION AND SUMMARIZED RESULTS.
- SEVEN FUNCTIONAL CATEGORIES DOCUMENTED FOR EACH CENTER
  - GENERAL PAYLOAD INVOLVEMENT, OPERATIONAL MODES
  - CONTROL CENTER AND/OR MONITORING CAPABILITIES
  - TRACKING AND DATA ACQUISITION CAPABILITIES
  - COMMUNICATIONS AND DATA HANDLING CAPABILITIES
  - COMPUTATION AND DATA MANAGEMENT CAPABILITIES
  - PAYLOAD TRAINING AND SIMULATION CAPABILITIES
  - PAYLOAD HOST FACILITIES

TASK d
ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

The objective of Task d was to define payload associated flight control ground functions required for each flight phase of given payload flight types and to allocate responsibility for those functions to the Payload Operator or STS Operator or both. Some functions were assigned to both Operators jointly or to one Operator monitored by the other.

The steps leading up to this allocation of functions included identification of applicable flight phases, developing guidelines for allocations, identification of the flight control ground functions (with input from Task a) and, finally, allocation to one of the five categories shown on the chart. These steps and summary of results are presented in subsequent charts.

TASK d
ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

OBJECTIVE: DEVELOP ALLOCATION OF PAYLOAD FLIGHT CONTROL GROUND FUNCTIONS BETWEEN THE PAYLOAD OPERATOR AND STS OPERATOR.

SUMMARY OF TASK RESULTS:

- ESTABLISHED THE FLIGHT PHASES APPLICABLE TO THE 14 GIVEN FLIGHT TYPES.
- THE 15 UNIQUE FLIGHT PHASES IDENTIFIED WERE CORRELATED WITH THE FLIGHT TYPES TO DETERMINE EXTENT OF FUNCTION REPEATABILITY.
- GENERAL GUIDELINES DEVELOPED FOR ALLOCATION OF THE FLIGHT CONTROL GROUND FUNCTIONS.
- GROUND FLIGHT CONTROL FUNCTIONS IDENTIFIED AND NUMBERED FOR EACH FLIGHT TYPE/PAYLOAD AND FLIGHT PHASE.
- EACH OF THE 666 FLIGHT CONTROL GROUND FUNCTIONS ALLOCATED (X) TO ONE OF THE FOLLOWING FIVE CATEGORIES:
  - PAYLOAD OPERATOR
  - PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE (MONITOR)
  - PAYLOAD OPERATOR AND STS OPERATOR
  - STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE (MONITOR)
  - STS OPERATOR

TASK d
FLIGHT TYPES AND REPRESENTATIVE PAYLOADS

This chart summarizes the payloads associated with each of the 14 flight types addressed by the study. These 14 flight types further break down into the three major categories, Automated Earth Orbit, Automated Planetary, and Spacelab, as shown.

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TASK d
FLIGHT TYPES AND REPRESENTATIVE PAYLOADS

CATEGORY	FLIGHT TYPE	REPRESENTATIVE PAYLOADS
AUTOMATED EARTH ORBIT	*LEO DELIVERY (E)	EARTH OBSERVATIONS SATELLITE (EOS)
	LEO DELIVERY AND RETRIEVAL (F)	LARGE SPACE TELESCOPE (LST) DELIVERY AND HIGH ENERGY ASTRO-PHYSICS OBSERVATORY RETRIEVAL
	LEO REVISIT/SERVICE W/O EVA (G)	EOS
	LEO REVISIT/SERVICE W/EVA (H)	LST
	LEO MULTICARGO DELIVERY (I)	BIOMEDICAL EXPERIMENTAL SCIENTIFIC SATELLITE (BESS), 2-MINI-LAGEOS, AND FREE-FLYER TELEOPERATOR
	LEO MULTICARGO POLAR ORBIT, SPACELAB AND 2 DELIVERIES TO LEO (J)	LIFE SCIENCES (SPACELAB MODULE), SPACE TEST PROGRAM (DOD), AND EXPLORER
	IUS MULTISATELLITE DELIVERY (K)	DISASTER WARNING SATELLITE (DWS), NOAA, AND FOREIGN COMMUNICATIONS SATELLITE (FCS)
	TUG MULTISATELLITE DELIVERY (M)	TRAFFIC MANAGEMENT SATELLITE (TMS), FAA, AND INTERNATIONAL COMMUNICATIONS SATELLITE (INTEL/SAT)
AUTOMATED PLANETARY	IUS PLANETARY (L)	MARINER
	TUG PLANETARY (N)	PIONEER
SPACELAB	MODULE AND PALLET, DEDICATED (A)	ADVANCED TECHNOLOGY LABORATORY (ATL)
	MODULE AND PALLET, MULTIDISCIPLINE (B)	**ATMOSPHERIC MAGNETOSPHERIC PLASMAS-IN-SPACE (AMPS) AND SPACE PROCESSING (SP)
	PALLET ONLY, DEDICATED (C)	SOLAR PHYSICS (SO)
	PALLET ONLY, MULTI-DISCIPLINE (D)	SO, STANDARD EARTH OBSERVATIONS PACKAGE FOR SHUTTLE (SEOPS), AND HIGH ENERGY ASTROPHYSICS (HEA)

*LEO = LOW EARTH ORBIT AND (E) REFERS TO FLIGHT TYPE IDENTIFIER IN TABLE 1.5-1.

**PARTIAL PAYLOADS APPROPRIATE IN THIS COMBINED CONFIGURATION.

TASK d
FLIGHT PHASE CODE

Fifteen flight phases were identified as being applicable to the 14 flight types assigned for this study. Two major categories of orbital vehicle configuration were addressed in designating these flight phases - one when the payload or payload/IUS/TUG are attached to the Orbiter, and the other when the payload or payload/IUS/TUG are separated from the Orbiter.

TASK d
FLIGHT PHASE CODE

1.	ORBITER-ASCENT
2.	ORBITER ON-ORBIT PAYLOAD ACTIVATION/CHECKOUT
3.	ORBITER-PAYLOAD DEPLOYMENT
4.	ORBITER ON-ORBIT PAYLOAD OPERATIONS
5.	ORBITER-PAYLOAD RETRIEVAL
6.	ORBITER-PAYLOAD SERVICING
7.	ORBITER-PAYLOAD DEACTIVATION
*8.	ORBITER-TUG/PAYLOAD DEPLOYMENT
*9.	TUG-ASCENT TO PARKING ORBIT
*10.	TUG ON-ORBIT ACTIVATION/CHECKOUT
*11.	TUG-PAYLOAD DEPLOYMENT/INJECTION
*12.	TUG ON-ORBIT PAYLOAD OPERATIONS
*13.	TUG-RETURN ORBIT
*14.	ORBITER-TUG/PAYLOAD RETRIEVAL
15.	ORBITER RE-ENTRY AND LANDING

*IUS WILL BE USED IN LIEU OF TUG INITIALLY

TASK d

CORRELATION OF STUDY FLIGHT TYPES AND FLIGHT PHASES

This chart shows the correlation of flight phases with the flight types identified in this study. It will be noted that only two flight phases, ORBITER-ASCENT and ORBITER-ON ORBIT PAYLOAD ACTIVATION AND CHECKOUT, are common to all flight types. The Orbiter re-entry and landing flight phase is addressed only when a cargo is aboard at landing. Several of the phases are unique to only a few flight types such as revisit/servicing flights, as shown.

There were 88 total flight phases addressed individually over the 14 flight types, or an average of approximately six flight phases per flight type.

TASK d.

CORRELATION OF STUDY FLIGHT TYPES AND FLIGHT PHASES

FLIGHT TYPE ID \ FLIGHT PHASE	1. ORBITER-ASCENT	2. ORBITER ON-ORBIT P/L ACTIV/CO	3. ORBITER-P/L DEPLOYMENT	4. ORBITER ON-ORBIT P/L OPNS	5. ORBITER-P/L RETRIEVAL	6. ORBITER-P/L SERVICING	7. ORBITER-P/L DEACTIVATION	*8. ORBITER-TUG-P/L DEPLOYMENT	*9. TUG-ASCENT TO PARKING ORBIT	*10. TUG ON-ORBIT ACTIVATION/CO	*11. TUG-PL DEPLOY/ORBIT INJECT	*12. TUG ON-ORBIT P/L OPERATIONS	*13. TUG-RETURN ORBIT	*14. ORBITER-TUG/PL RETRIEVAL	15. ORBITER RE-ENTRY AND LANDING
A	X	X		X			X								X
B	X	X		X			X								X
C	X	X		X			X								X
D	X	X		X			X								X
E	X	X	X				X								
F	X	X	X		X		X								X
G	X	X	X		X	X	X								X
H	X	X	X		X	X	X								X
I	X	X	X				X								
J	X	X	X	X			X								X
K	X	X					X	X	X	X	X	X			
L	X	X					X	X	X	X	X	X			
M	X	X						X	X	X	X	X	X	X	
N	X	X						X	X	X	X	X	X	X	

* IUS WILL BE USED IN LIEU OF TUG INITIALLY.

NOTE:

FLIGHT TYPES ARE IDENTIFIED ON PREVIOUS CHART

TASK d

GENERAL GUIDELINES FOR GROUND FUNCTION ALLOCATION

This chart identifies the general guidelines used in allocating the flight control ground functions to one of the function assignee categories. In cases where allocation of functions was not completely clear-cut, the allocation was generally made toward greater Payload Operator responsibility then STS Operator.

It should be noted that both the Payload Operator and the STS Operator are involved in three of the five categories and that each has some responsibility in four of the five categories.

TASK d

GENERAL GUIDELINES FOR GROUND FUNCTION ALLOCATION

FUNCTION ASSIGNEE	APPLICABLE GUIDELINES
PAYLOAD OPERATOR	• PAYLOAD FUNCTIONS WHILE IN FREEFLYING MODE (NOT ATTACHED TO ORBITER OR IUS/TUG) • NON-HAZARDOUS PAYLOAD EXPERIMENTS FUNCTIONS (PAYLOAD ATTACHED TO STS ELEMENT) • PAYLOAD/SUPPORT FUNCTIONS NOT REQUIRING STS
PAYLOAD OPERATOR W/STS OPERATOR COGNIZANCE	• PAYLOAD EXPERIMENT FUNCTIONS INVOLVING POTENTIAL HAZARD TO STS • PAYLOAD FUNCTION UTILIZES STS CONSUMABLES • PAYLOAD FUNCTION IMPACTS STS TIMELINES • CRITICAL PAYLOAD FUNCTIONS MONITORING • GO/NO-GO FOR CONTINUING FLIGHT • PAYLOAD EXPERIMENT FAULT ANALYSIS
PAYLOAD OPERATOR AND STS OPERATOR	• HANDOVER FUNCTIONS BETWEEN STS-PAYLOAD OPERATORS • OTHER FUNCTIONS INVOLVING JOINT STS-PAYLOAD OPERATOR ACTIVITY • FUNCTIONS THAT MUST BE PERFORMED BY BOTH STS AND PAYLOAD OPERATORS (CONSUMABLES MANAGEMENT)
STS OPERATOR W/PAYLOAD OPERATOR COGNIZANCE	• STS SUBSYSTEMS OPERATIONS THAT SUPPORT OR SERVICE PAYLOAD OPERATIONS, SUCH AS TRAJECTORY POSITIONING AND POINTING • STS OPERATOR FUNCTIONS REQUIRING SUPPORT OF PAYLOAD OPERATOR, SUCH AS VERIFICATION OF THE CENTER COMMUNICATIONS INTERFACES
STS OPERATOR	• POWERED FLIGHT • SAFETY MONITORING • SERVICE FUNCTIONS TO PAYLOAD OPERATOR, SUCH AS CARGO BAY ENVIRONMENT MONITORING, VERIFYING ORBITER-PAYLOAD CONNECTIONS, ETC. • STANDARD (REPETITIVE) SERVICE FUNCTIONS, SUCH AS DATA TRANSMISSIONS • STS FUNCTIONS REQUIRED TO EFFECT REQUIRED CONDITIONS FOR PAYLOAD OPERATIONS

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

The following five charts were extracted from the Final Report, Volume II-D, to provide examples of the flight control ground functions considered in the Study and to show how Operator assignments were identified.

Each function is uniquely identifiable by Flight Type - Flight Phase - Function Number; for example, Function A-1-3 uniquely identifies the function, MAINTAIN TEMPERATURE OF BIOLOGICAL REFRIGERATOR, and the prefix "A-1" indicates the function is included in Flight Type "A", Flight Phase "1", which are "Spacelab Module and Pallet, Dedicated" and "Orbiter-Ascent", respectively.

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

FLIGHT TYPE: A SPACELAB MODULE AND PALLET, DEDICATED

PAYLOAD: ADVANCED TECHNOLOGY LABORATORY (ATL)

FLIGHT PHASE: 1 ORBITER-ASCENT

FUNCTION / OPERATOR ASSIGNMENT	PAYLOAD OPERATOR	PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE	PAYLOAD OPERATOR AND STS OPERATOR	STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE	STS OPERATOR
1. MONITOR PAYLOAD TELEMETRY; VERIFY CRITICAL FUNCTIONS WITHIN OPERATING LIMITS		X			
2. VERIFY ORBITER BAY TEMPERATURE, PRESSURE, CLEANLINESS ENVIRONMENT WITHIN LIMITS REQUIRED BY ATL				X	
3. MAINTAIN TEMPERATURE OF BIOLOGICAL REFRIGERATOR	X				
4. MONITOR STATUS OF PAYLOAD - ORBITER HARDLINE CONNECTIONS					X
5. DETERMINE GO/NO-GO FOR CONTINUING FLIGHT PHASE					X

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

Sample allocations continued.

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

FLIGHT TYPE: A SPACELAB MODULE AND PALLET, DEDICATED

PAYLOAD: ADVANCED TECHNOLOGY LABORATORY (ATL)

FLIGHT PHASE: 2 ORBITER ON-ORBIT PAYLOAD ACTIVATION AND CHECKOUT

FUNCTION / OPERATOR ASSIGNMENT	PAYLOAD OPERATOR	PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE	PAYLOAD OPERATOR AND STS OPERATOR	STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE	STS OPERATOR
1. MONITOR PAYLOAD TELEMETRY; VERIFY CRITICAL FUNCTIONS WITHIN OPERATING LIMITS		X			
2. VERIFY PAYLOAD PYROTECHNICS NOT ARMED		X			
3. VERIFY ORBITER BAY TEMPERATURE, PRESSURE, CLEANLINESS ENVIRONMENT WITHIN LIMITS REQUIRED BY ATL				X	
4. VERIFY OPERATION OF ALL ORBITER SUBSYSTEMS WHICH SUPPORT THE ATL				X	
5. STIMULATE ATL COMMAND SYSTEM; VERIFY FUNCTIONAL STATUS		X			
6. SET UP, CALIBRATE AND CHECKOUT PAYLOAD INSTRUMENTS AND EQUIPMENT	X				
7. DEPLOY BOOM AND ESTABLISH INITIAL POINTING		X			
8. IF REQUIRED, PARTICIPATE WITH CREW IN FAULT ANALYSIS AND ISOLATION		X			
9. INPUT VEHICLE ORIENTATION PARAMETERS FOR ATL				X	
10. DETERMINE GO/NO-GO FOR CONTINUING FLIGHT			X		

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

Sample allocations continued.

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

FLIGHT TYPE: A SPACELAB MODULE AND PALLET, DEDICATED

PAYLOAD: ADVANCED TECHNOLOGY LABORATORY (ATL)

FLIGHT PHASE: 4 ORBITER ON-ORBIT PAYLOAD OPERATIONS

(CONTINUED)

FUNCTION / OPERATOR ASSIGNMENT	PAYLOAD OPERATOR	PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE	PAYLOAD OPERATOR AND STS OPERATOR	STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE	STS OPERATOR
11. CALCULATE POINTING ANGLES FOR EARTH-LOOKING INSTRUMENTS USING PRINCIPAL INVESTIGATORS EXPERIMENT REQUIREMENTS	X				
12. MONITOR STS AND PAYLOAD GROUND DATA SYSTEM STATUS AND PERFORMANCE; ANALYZE SYSTEM ANOMALIES			X		
13. OPERATE AND MONITOR THE EXPERIMENTS THAT CAN BE CONTROLLED FROM POC, MAINTAIN COMMAND LOG	X				
14. MAINTAIN INTERFACES BETWEEN POC AND STS MCC				X	
15. MAINTAIN INTERFACES WITH ANCILLARY AGENCIES REQUIRED BY INDIVIDUAL PAYLOADS	X				

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

Sample allocations continued.

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

FLIGHT TYPE: A SPACELAB MODULE AND PALLET, DEDICATED

PAYLOAD: ADVANCED TECHNOLOGY LABORATORY (ATL)

FLIGHT PHASE: 7 ORBITER-PAYLOAD DEACTIVATION

FUNCTION / OPERATOR ASSIGNMENT	PAYLOAD OPERATOR	PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE	PAYLOAD OPERATOR AND STS OPERATOR	STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE	STS OPERATOR
1. MONITOR PAYLOAD TELEMETRY; VERIFY SYSTEMS STATUS FOR RE-ENTRY		X			
2. VERIFY DEACTIVATION OF ALL ORBITER SUBSYSTEMS NO LONGER REQUIRED TO SUPPORT ATL				X	

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

Sample allocations continued.

TASK d

ALLOCATION OF FLIGHT CONTROL GROUND FUNCTIONS

FLIGHT TYPE: A SPACELAB MODULE AND PALLET, DEDICATED

PAYLOAD: ADVANCED TECHNOLOGY LABORATORY (ATL)

FLIGHT PHASE: 15 ORBITER RE-ENTRY AND LANDING

FUNCTION / OPERATOR ASSIGNMENT	PAYLOAD OPERATOR	PAYLOAD OPERATOR WITH STS OPERATOR COGNIZANCE	PAYLOAD OPERATOR AND STS OPERATOR	STS OPERATOR WITH PAYLOAD OPERATOR COGNIZANCE	STS OPERATOR
1. MONITOR PAYLOAD TELEMETRY; VERIFY SYSTEMS STATUS		X			
2. VERIFY ORBITER BAY TEMPERATURE, PRESSURE, CLEANLINESS ENVIRONMENT WITHIN LIMITS REQUIRED BY ATL				X	

TASK e

OPERATIONAL INFORMATION FLOW AND PROCESSING

The objective for Task e was to develop a model and methodology to determine the operational flight control information flow and operational data processing required to implement the flight control task with the operational interfaces.

The methodology and model were generated which describe the approach to derive the communications and operational data processing information requirements at the major interfaces between the key elements of the STS payload ground network.

Flight control data base capabilities and plans for each site were reviewed. The requirements for a Supervisory Data Base Management System were recommended.

The system enhancement requirements for a baseline system concept were determined based on using GSFC, JPL, and JSC as the primary Payload Flight Control Centers for automated earth orbit, planetary and Spacelab payloads, respectively.

TASK e

OPERATIONAL INFORMATION FLOW AND PROCESSING

OBJECTIVE: DEVELOP A MODEL AND METHODOLOGY TO IDENTIFY COMMUNICATIONS CHANNELS AND DATA PROCESSING REQUIREMENTS BETWEEN STS PAYLOAD FLIGHT CONTROL ELEMENTS.

SUMMARY OF TASK RESULTS:

- METHODOLOGY AND MODEL FOR DERIVING COMMUNICATION AND DATA PROCESSING TRAFFIC LEVELS
- RECOMMENDATIONS FOR A SUPERVISORY DATA BASE SYSTEM FOR STS PAYLOAD FLIGHT CONTROL
- SYSTEM ENHANCEMENT REQUIREMENTS FOR BASELINE SYSTEM CONCEPT

TASK e

SEQUENTIAL FLOW OF MODEL GENERATION

The objective of this effort was to identify the communications channels and transfer functions between team members and system elements of the STS Payload operational system.

This was accomplished by generating a model along with establishing the methodology such that when implemented with a computer program, meaningful data can be derived.

The Sequential Flow of Model Generation depicts the methodology for applying the model (this technique was presented in detail at the Midterm Progress Review).

1. SSPD Documents - Used as primary source for specific Payload data.

2. Payload Data Summary Worksheets (Per P/L) - Provides Forward/Return Link data for Prelaunch C/O, P/L Deployment from Orbiter, IUS and Tug, and P/L Operational Phases for each Payload.

3. Payload Data Summary Worksheets (Per P/L Flight Type) - Accumulates data for each P/L from 2. into worst case data per Flight Type.

4. N^2 Charts - Establishes operational interfaces (nodes) between the primary functional Payload centers for each phase and P/L type.

5. Payload Simultaneous Operations Charts - Provides quantity of each Payload Flight Type operating at the same time.

6. Payload Flights/Year Traffic Model - Provides quantity of flights per Payload type per year.

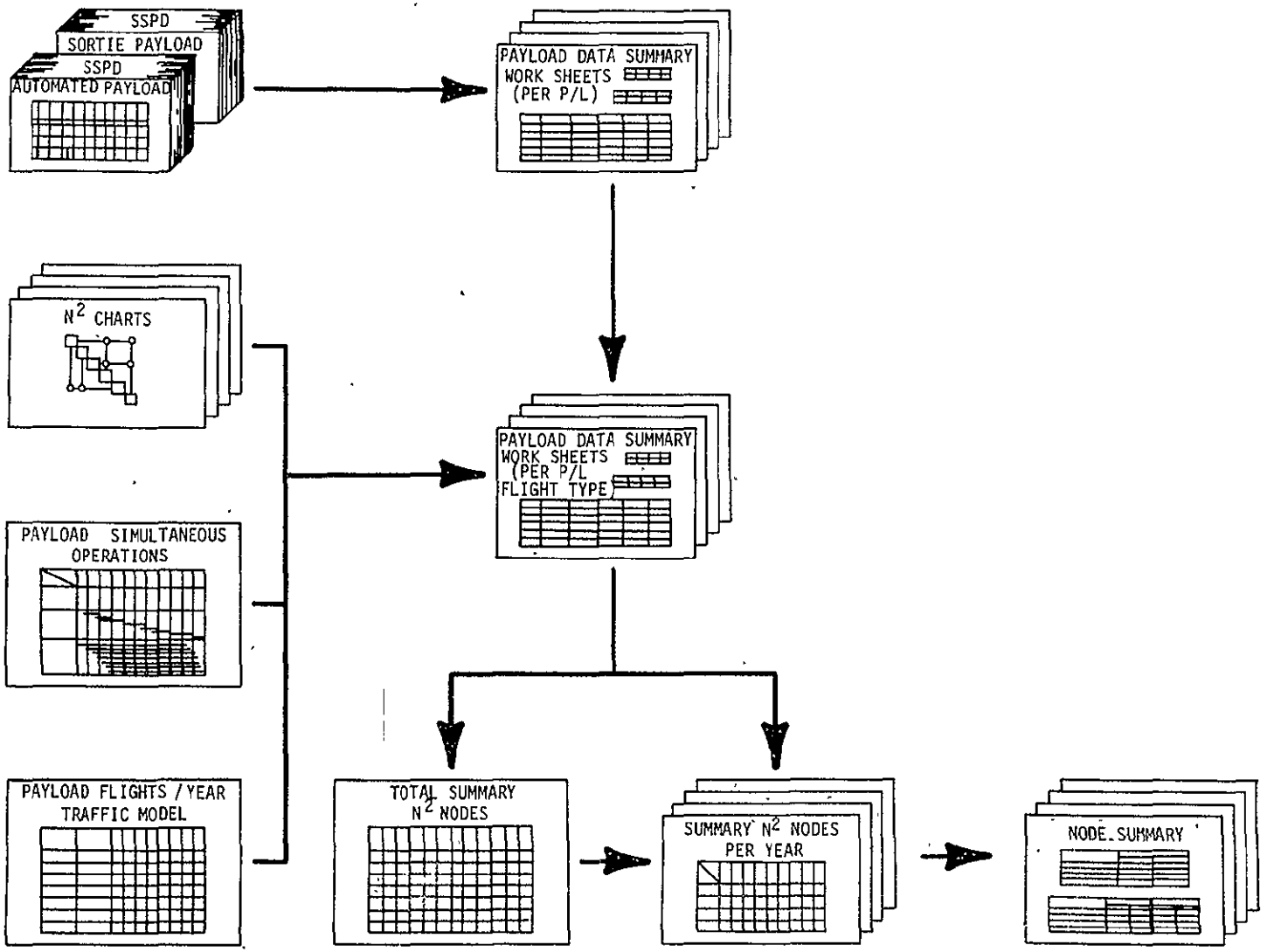
7. Total Summary N^2 Nodes - Presents the node totals for all representative flight types and phases.

8. Summary N^2 Nodes Per Year - Depicts same info as 7. per year plus the number of launches and overlap operations per year.

9. Node Summary - Provides a summary of the total data for a specific interface node during a year.

TASK e

SEQUENTIAL FLOW OF MODEL GENERATION



TASK e

CONCLUSIONS FROM COMMUNICATION AND DATA FLOW ANALYSIS

Three sample Payload Flight Types were evaluated using the methodology and model for communication and data flow analysis; Spacelab - Dedicated Module & Pallet (A), Low Earth Orbit - Single Cargo - Delivery (E), and Planetary - IUS (L).

From information derived from the SSPD Documents, it was determined that only one of the study representative payloads exceeded T1 communication circuit bandwidth: EOS-200 Mb/s.

In order to thoroughly evaluate the complete interface (Node) requirements, the Methodology and Model should be implemented into a software program. Since this model solves for Worst Case conditions, it is recommended that the model also be expanded to incorporate the Most Probable operational overlap conditions.

TASK e

CONCLUSIONS FROM COMMUNICATION AND DATA FLOW ANALYSIS

- THREE SAMPLE CASES WERE TESTED WITH THE MODEL
- ONLY ONE PAYLOAD WITH VERY HIGH DATA RATE IDENTIFIED
- NEED FOR SOFTWARE MECHANIZATION OF MODEL AND REDUCTION TO "MOST PROBABLE" IN ADDITION TO "WORST CASE"

TASK e

DATA BASE APPLICATIONS CHART

The Data Bases required are gross data base categories identified as the major categories for Payload Operations.

In addition to indicating the Data Base Participants associated with each type of data base, the chart depicts approximations of 3 types of processing:

Query Rates - Frequency Data Base is exercised

Update Requirement - Frequency Data Base is modified

Active Historical Span - Time Data Base is stored in normal access mode.

The Data Bases required are:

1. Control of DB System (Directory) - Complete definition and instructions for use of all STS and PL Data Bases.

2. PI/User DB - Payload experiment data required only by the PI.

3. SSPD Data Base - SSPD design and operation data for each PL.

4. Universal Document System DB - Library of both manual and computerized storage, divided into STS and Payload data categories.

5. Interface Control Documents DB - ICD's for PL/Orbiter, PL/Spacelab, PL/Tug or IUS, and PL/Launch and Landing Facility.

6. Communication Tracking System - Includes acquisition and control data, orbit determination, and maneuvering data.

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TASK e

DATA BASE APPLICATIONS

DATA BASES REQUIRED	DATA BASE PARTICIPANTS									TYPES OF PROCESSING		
	ARC	GSFC	JPL	JSC	KSC	MCC	MSFC	STC	VAFB	QUERY RATE	UPDATE REQUIREMENT	ACTIVE HISTORICAL SPAN
1. CONTROL OF D.B. SYSTEM (DIRECTORY)	X	X	X	(X)	X	X	X	X	X	MULTI-H	H	H
2. PRINCIPAL INVESTIGATOR/USER D.B. (POCS)	(X)	(X)	(X)	(X)			(X)	(X)		H	H	L
3. SSPD DATA BASE							(X)			H	H	H
4. UNIVERSAL DOCUMENT SYSTEM				(X)						L	L	H
5. INTERFACE CONTROL DOCUMENTS				(X)	X	X	(X)	X	X	L	L	H
6. COMMUNICATION & TRACKING SYSTEM		(X)	(X)	(X)				(X)		H	H	H
7. MASTER MEASUREMENTS D.B.				(X)						L	L	H
8. PROBLEM REPORTING & CORRECTIVE ACTION	(X)	(X)	(X)	(X)		S	(X)	(X)		H	H	H
9. LAUNCH/LANDING PROCESS SYSTEM					(X)				X	H	H	H
10. PAYLOAD PECULIAR D.B.	(X)	(X)	(X)	(X)		X	(X)	(X)		H	H	H
11. TELEMETRY & DATA ACCOUNTING SYSTEM D.B.	(X)	(X)	(X)	(X)		X	(X)	(X)		H	H	H
12. AE/SL ASTRONOMY							(X)			H / H	H / H	H / H
13. AE/SL HIGH ENERGY ASTROPHYSICS							(X)			H / H	H / H	H / H
14. AE/SL SOLAR PHYSICS		(X)					(X)			H / H	H / H	H / H
15. AE/SL ATMOSPHERIC & SPACE PHYSICS		(X)								H / H	H / H	H / H
16 AE/SL EARTH OBSERVATIONS		(X)		(X)			(X)			H / H	H / H	H / H
17. AE/SL EARTH & OCEAN PHYSICS		(X)								H / H	H / H	H / H
18. AE/SL SPACE PROCESSING				(X)			(X)			H / H	H / H	H / H
19. AE/SL LIFE SCIENCES	(X)			(X)			(X)			H / H	H / H	H / H
20. AE/SL SPACE TECHNOLOGY				(X)						H / H	H / H	H / H
21. AP PLANETARY	(X)		(X)							H	H	H
22. * COMMUNICATION & NAVIGATION				X						NA	NA	NA
23 AP LUNAR		(X)		(X)						H	H	H

LEGEND

AE AUTOMATED EARTH ORBIT
AP AUTOMATED PLANETARY
SL SPACELAB

DURING PAYLOAD OPERATIONAL PHASE { H = HIGH, M = MEDIUM, L = LOW

S = SHARED D.B.
X = USER (COMMON ACCESS)
(X) = HOST D.B.

* NON-NASA PAYLOADS ONLY
** INFREQUENT: <10 ACCESSES PER DAY
MODERATE 10-100 ACCESSES PER DAY
FREQUENT >100 ACCESSES PER DAY

L** = INFREQUENT, M** = MODERATE, H** = FREQUENT
L = MONTHLY, M = WEEKLY, H = DAILY
H = 2 TO 10 YEARS, M = UP TO 2 YEARS, L = MONTHLY OR LESS

TASK e

DATA BASE APPLICATIONS CHART (CONTINUED)

7. Master Measurements Data Base - PL/STS measurements derived from all testing and accumulated telemetry data. Used for troubleshooting and fault isolation.

8. Problem Reporting and Corrective Action DB - Test Data to support the detection, fault isolation, and correction of STS/PL and PL peculiar operations.

9. Launch/Landing Process System DB - Payload launch and landing support data including test and checkout data.

10. Payload Peculiar DB - Generated and maintained at the POC includes PL operation and experiment data.

11. Telemetry and Data Accounting System Data Base - PL housekeeping trend analysis control and predictions, orbital and tracking data, etc.

12. Scientific Experiment DB Categories - 12 through 23 on the chart are defined in Task "a" and the SSPD Documents.

TASK e

DATA BASE APPLICATIONS CHART (CONTINUED)

(Same as previous chart)

TASK e

STS/PAYLOAD DATA BASE INTERFACE CONCEPT

This chart depicts a centralized/distributive method by which the STS/Payload Data Bases could be interfaced.

The Data Base interfaces at GSFC, JPL, and JSC are shown with the user and NASA common data. ARC is shown as an overlapping function to indicate that its payload operations will probably receive data base support from JPL. MCC-H is shown as an overlapping function with JSC because of its probable utilization of JSC data base facilities. Also, MCC-H will share STS characteristics and constraints data base information with the payload world.

KSC and VAFB each will possibly provide launch and landing data base support. VAFB is shown as an overlapping function with KSC to indicate the duplication of the types of data bases.

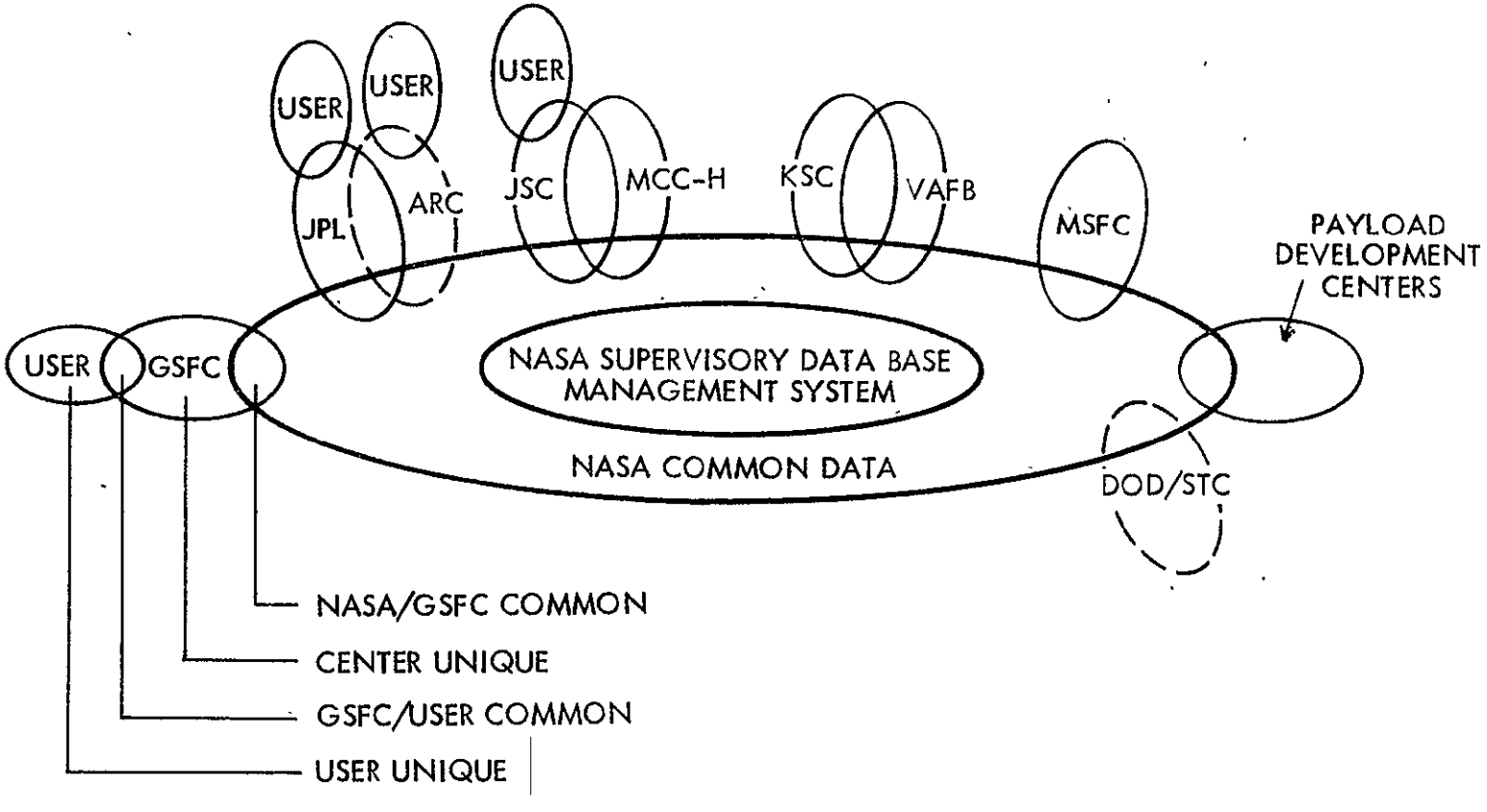
MSFC will provide the SSPD Data Base and the Payload Traffic Model Data Base information.

The Payload Development Centers will possibly provide payload peculiar data base information including test data to support Payload operational maintenance and troubleshooting.

The STC data base interface will probably be primarily with the MCC-H for its operational functions.

TASK e

STS/PAYLOAD DATA BASE INTERFACE CONCEPT



TASK e

TYPICAL POC FUNCTIONAL FLOW

POCC FUNCTIONS (Inner Circle)

1. Experiment Monitor and Control - Strip and format data for processing, provides data to Mission Ops and Control Center, evaluate raw data, monitor status of data, Quick Look process, In Depth data evaluation, and generate operational data.
2. Command and Control Processing - Generate commands, verification, monitor command operations, and maintain command logs.
3. Telemetry Input Processing - Receive data and reformat if required, decommutate data, process and output data, and generate displays for telemetry data.
4. Attitude Data Processing - Strip and output attitude data to the Central Facility, and monitor data quality.
5. Operations and Control - Direct PL operations and control, responsibility for PL command and control, execute PL plans, evaluate and control PL activities, and plan - control - and evaluate ground support activities.
6. Flight Planning and Control - Evaluation of PL system, coordinates PI support and PL health requirements, and technical evaluation of total PL/ground support system.

CENTRAL FACILITY PROCESSING FUNCTIONS

1. Orbit Determination
2. Flight Maneuver Computations
3. Attitude Computations
4. Payload Control Processing
5. Experiment Data Processing
6. Data Base Management, Storage, and Retrieval

SPECIAL PURPOSE COMPUTATION ALTERNATIVES

1. PI may bring mini-computer and software to POCC.
2. Integrate user requirements into institutional computing capability at NASA Center.
3. Host facility may implement user requirements into existing operational capability.
4. User requirements may be integrated through use of a portable remote POCC at the users location.

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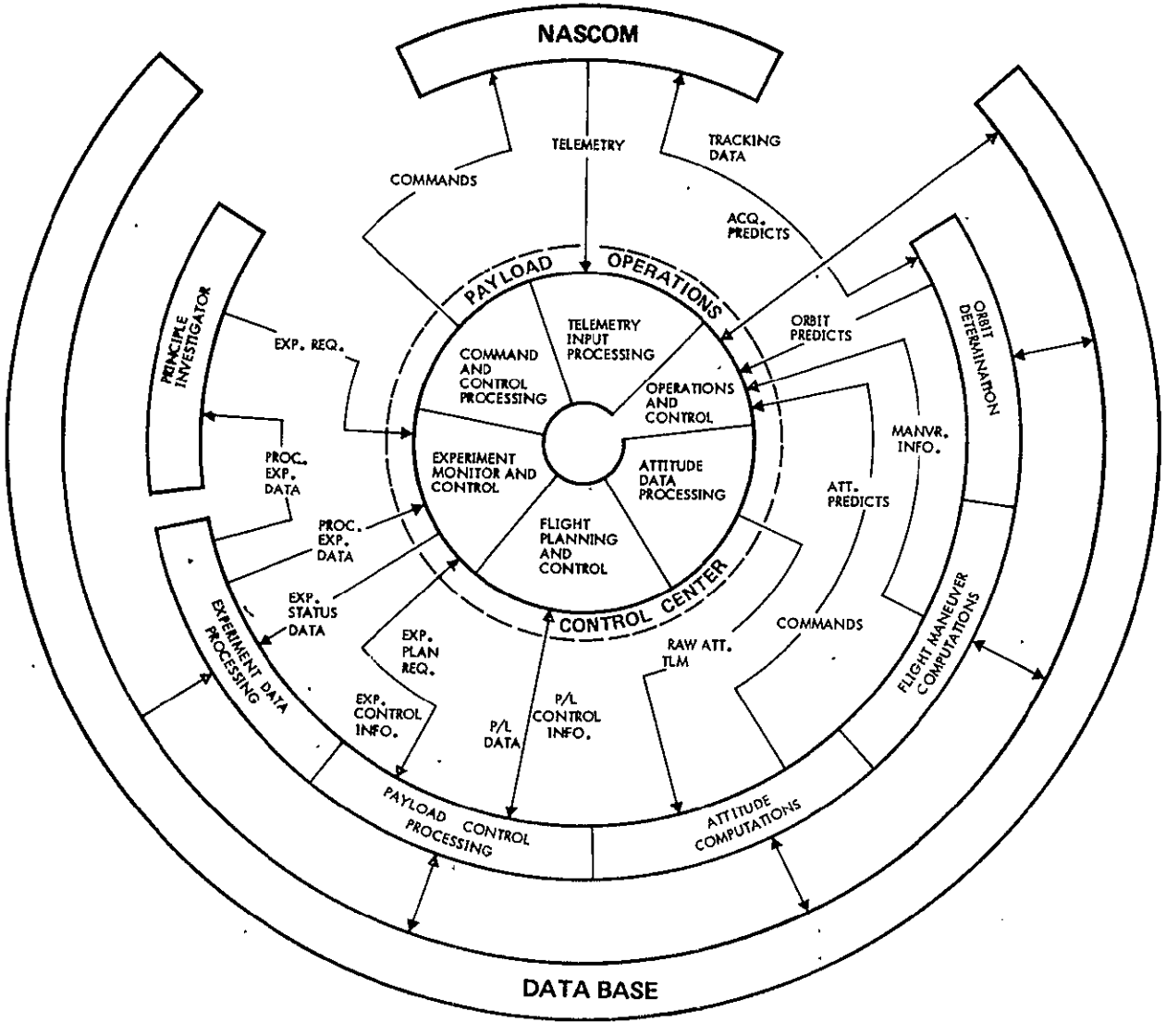
TASK e
TYPICAL POC FUNCTIONAL FLOW



TASK e

JSC PAYLOAD OPERATIONS CENTER CONCEPT

This chart depicts the recommended Spacelab POC system concept.

The POC Elements are:

1. POCC Clusters - Based on past experience and planned capabilities, the POCC Cluster Types at JSC will consist of: Earth Resources, Life Sciences, Astronomy, Science and Technology, and Multidisciplines.

2. Data Communications Subnet - A network of interface processors which provide for interconnecting the clusters, the large scale computers and the NASCOM Interface Processor.

3. Storage System - The Data Base Management system including mass storage and retrieval of data base information.

4. Large Scale Computer Support - Use of the Central Computer Facility to provide off line support to the POCC's. Support consists of experiment processing and payload attitude and orbit determination.

5. Information Processing Support - Use of the RTCC Facility to provide real/time and near real/time support for PL telemetry and experiment processing.

A Typical POCC consists of:

1. VIP (Virtually Interfaced Peripherals) - A minicomputer that interfaces peripheral devices (CRT terminals, printers, etc.) to the communications subnet. It provides both virtual and real mapping functions for its peripheral.

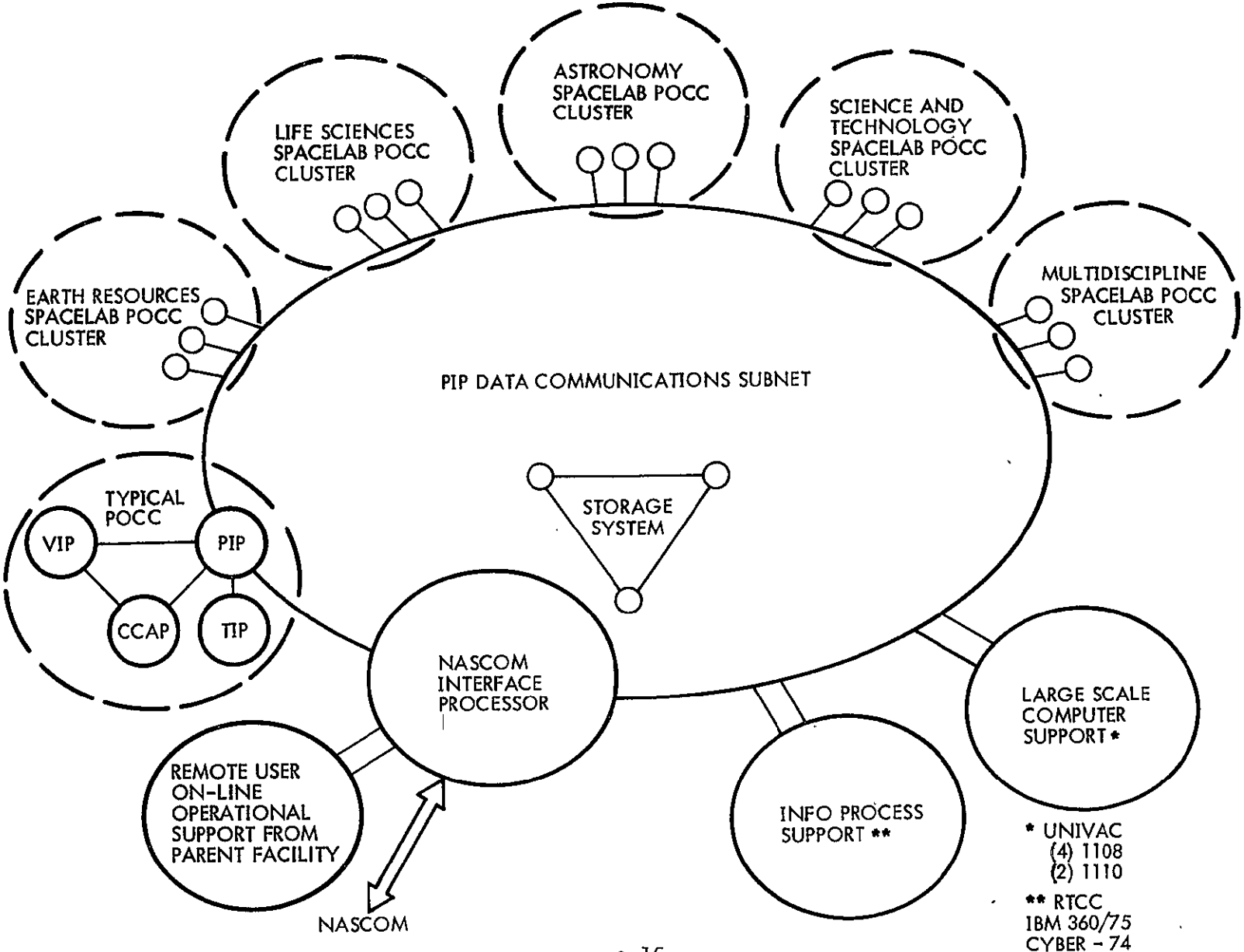
2. PIP (POCCNET Interface Processor) - A minicomputer that provides for the POCC interface with the remainder of the Center's Facilities.

3. TIP (Telemetry Input Processor) - Minicomputer which receives and processes all telemetry signals addressed to its associated POCC.

4. CCAP (Control Center Applications Processor) - A medium scale computer which supports telemetry conversion, provides command processing and supports the control and monitor consoles and displays.

TASK e

JSC PAYLOAD OPERATIONS CENTER CONCEPT



TASK e

GSFC PAYLOAD OPERATIONS CENTER CONCEPT

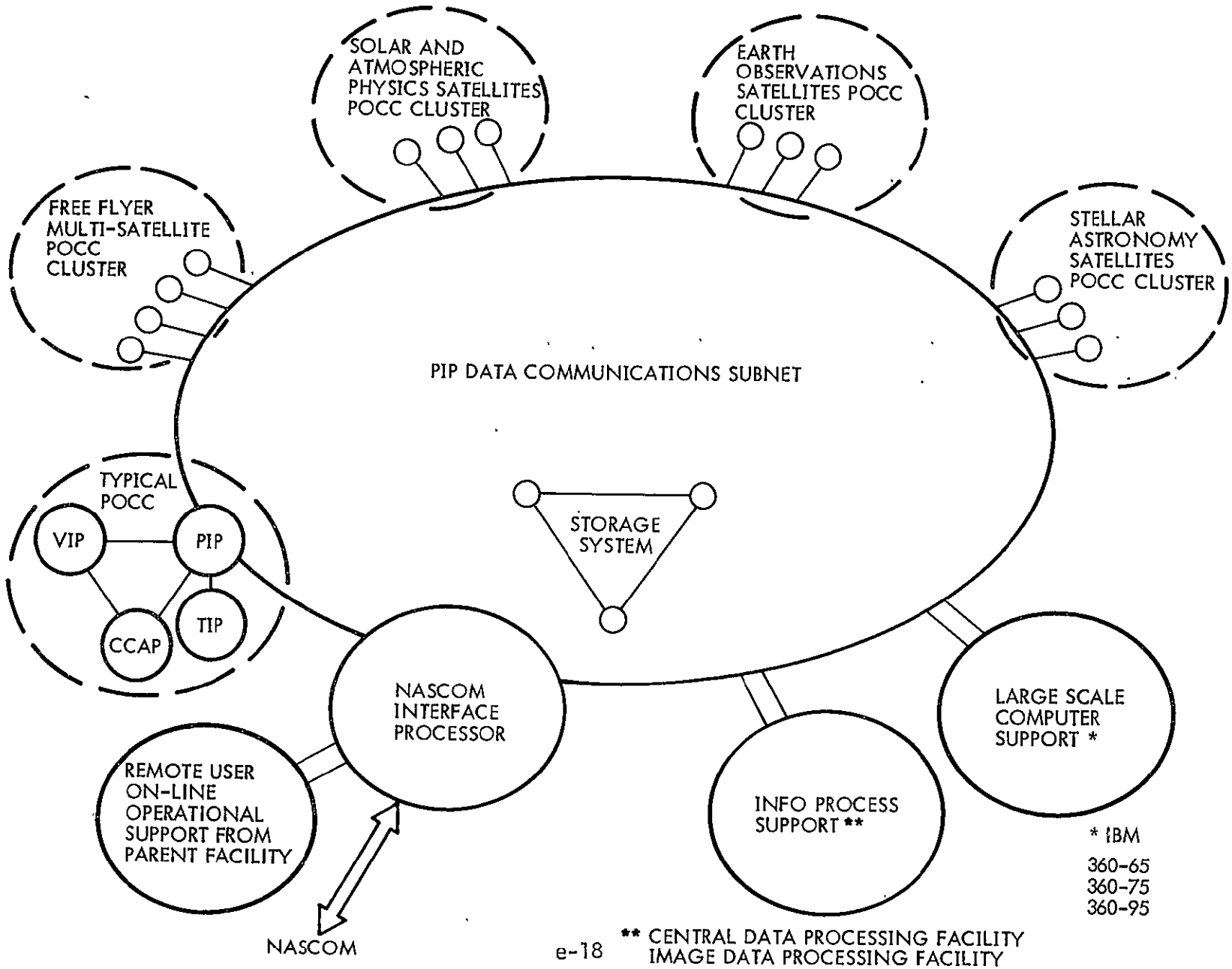
This chart depicts the planned GSFC POCCNET concept.

Based on past experience and planned capabilities, the POCC Cluster types of GSFC would consist of: Free Flyer Multi-Satellite, Solar and Atmospheric Physics Satellites, Earth Observations Satellites, Stellar Astronomy Satellites, and Spacelab Payloads.

The Large Scale Computer Support could be provided by the planned IBM 360-65, 360-75, and 360-95 systems.

The Information Processing Support could be provided by the Central Data Processing Facility and the Image Data Processing Facility.

TASK e
GSFC PAYLOAD OPERATIONS CENTER CONCEPT



** CENTRAL DATA PROCESSING FACILITY
IMAGE DATA PROCESSING FACILITY

TASK e

JPL PAYLOAD OPERATIONS CENTER CONCEPT

This chart depicts a JPL Planetary POC concept.

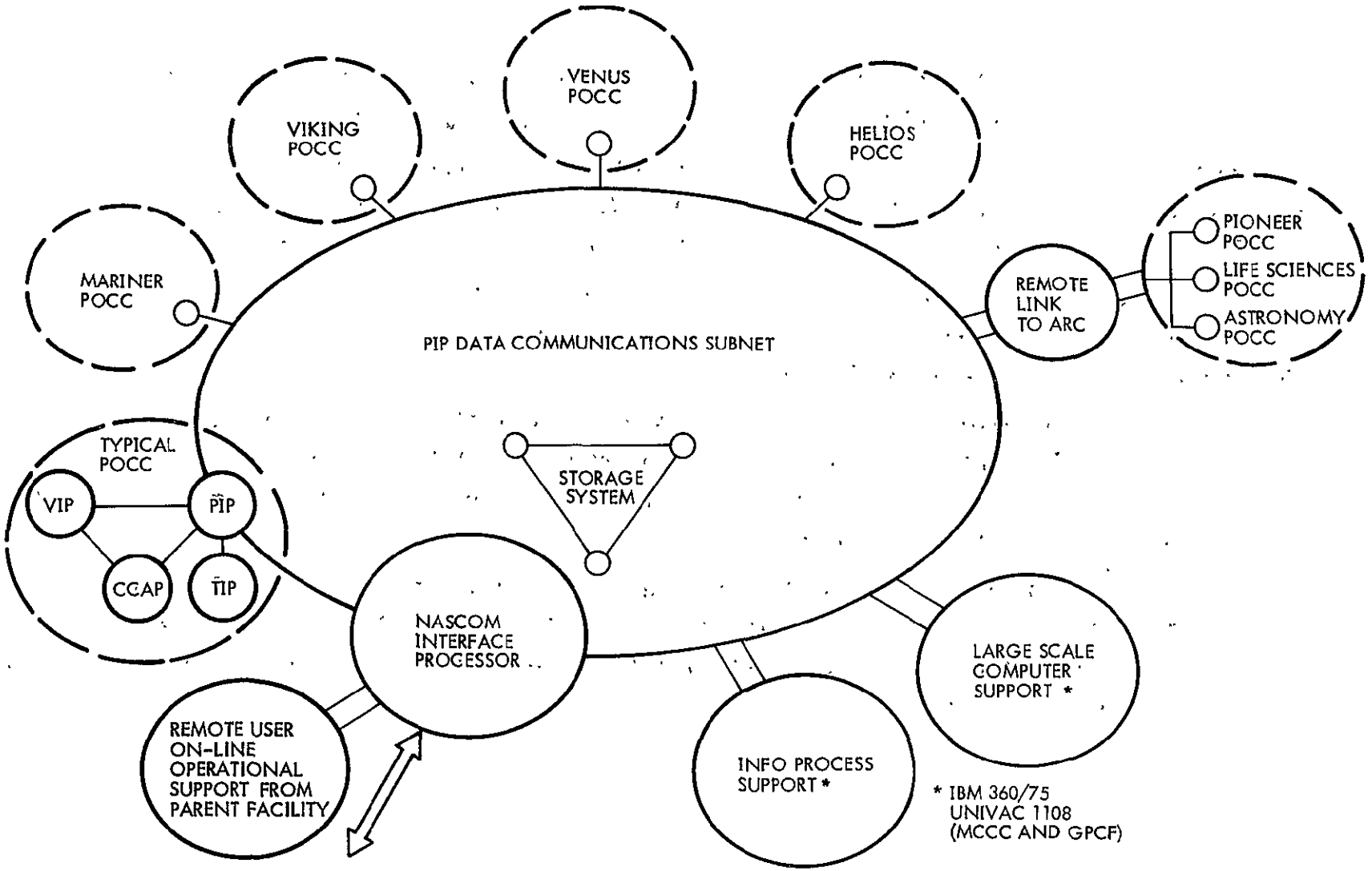
Based on past experience and planned capabilities, the POCC types at JPL would include: Mariner, Viking, Venus, and HELIOS.

Pioneer, Life Sciences and Astronomy POCC's can be located at ARC, operating as a remote facility in coordination with JPL.

Large Scale Computer and Information Processing Support would use the Mission Control and Computing Center (MCCC) and the General Purpose Computing Facility (GPCF).

TASK e

JPL PAYLOAD OPERATIONS CENTER CONCEPT



TASK e

IMPLEMENTATION PHASING

System enhancements discussed under Task e are recommended for implementation under the phasing schedule for Task f implementation which is shown on the adjacent page.

Phase I extends from the present time through 1980. Major activities during this phase are to complete the definition of system requirements for an evolutionary NASA-wide system for STS payload support and to complete the implementation for the Phase II system.

Phase II covers the period from 1980 to 1983 and will be termed the "baseline system". This is the initial three center capability for STS payload support. During this phase, implementation for Phase III must be completed.

Phase III extends from 1983 to 1986 and is termed the "transition phase"; not to be confused with the STS transition phase. This is the period of transition from the baseline capability to the "all-up" systems capability for STS payload support. Implementation for Phase IV must be completed during this phase.

Phase IV is the fully operational phase and the ultimate system configuration should be ready at the beginning of this phase. During this phase STS payloads will operate in a fully integrated NASA-wide STS payload support system which utilizes standard POCC's and standard procedures to the extent practical.

TASK e

IMPLEMENTATION PHASING

- SYSTEM ENHANCEMENTS MENTIONED IN TASK e ARE INCLUDED IN TASK f IMPLEMENTATION PHASING. PHASE DEFINITIONS ARE AS FOLLOWS:

- PHASE I	1976-1980 REQUIREMENTS DEFINITION	COMPLETE REQUIREMENTS DEFINITION FOR ALL-UP SYSTEM. COMPLETE IMPLEMENTATION FOR PHASE II SYSTEM.
- PHASE II	1980-1983 BASELINE SYSTEM	AUGMENTED EXISTING CAPABILITY. IMPLEMENTATION FOR PHASE III.
- PHASE III	1983-1986 TRANSITION PHASE	BUILD TOWARD FULL CAPABILITY. IMPLEMENTATION FOR PHASE IV.
- PHASE IV	1986-1991 FULLY OPERATIONAL	FULLY INTEGRATED NASA-WIDE STS PAYLOAD SUPPORT SYSTEM.

TASK e

JSC SPACELAB PAYLOAD OPERATIONS CENTER ENHANCEMENT REQUIREMENTS

The basic approach in the establishment of the Enhancement Requirements for the JSC Spacelab POC is based on:

1. POCCNET approach planned at the GSFC. The POCC plans by JPL are similar to the POCCNET plan.
2. At least during the Phase I period and possibly during Phase II, it should be planned to use the existing computer facilities as well as existing experiment, Skylab, and ASTP facilities. This provides a baseline for later facility expansion.
3. The past experience and existing capabilities of JSC make it the logical choice for recommendation as the Spacelab POC. Earth Resource, Life Science and Manned Spacecraft capabilities presently exist at JSC.

The schedule for development of the POC facilities is:

1. Phase I (1976 thru 1979) - Full support to the OFT program and all associated payloads. Expand POC capability as practicable; use STS facilities which are available.
2. Phase II (1980 thru mid 1983) - Expand the POCC facilities to meet the flight requirements.

TASK e

JSC SPACELAB PAYLOAD OPERATIONS CENTER ENHANCEMENT REQUIREMENTS

BASIC APPROACH

- BASED ON POC PLANS FOR GSFC & JPL
- USE EXISTING CAPABILITIES
- PAST EXPERIENCE

SCHEDULE

- 1976 THRU 1979 : PHASE I, IMPLEMENTATION FOR PHASE II
- 1980 THRU MID 1983 : PHASE II (BASELINE SYSTEM)

TASK e

SUMMARY OF ENHANCEMENT REQUIREMENTS

The following are the recommended system enhancements which should be considered for the Payload Operational Phases III and IV (mid-1983 through 1991):

1. Baseline NASA Payload Centers

   Automated Earth Orbit - GSFC
   Spacelab - JSC
   Planetary - JPL

2. Standard POC System Concept

   As a first step toward maximum standardization, the POCCNET system design planned by GSFC is recommended for all Centers. JPL is presently planning a similar approach.

3. Data Base Management Concept

   Anticipated Payload traffic during the early 1980's does not necessitate a complex DB management system between Centers; however, a centralized supervisory DBM system should be implemented at the earliest opportunity.

4. Communication and Data Acquisition

   Based on the projected low Phase II Payload traffic and planned bandwidth requirements, it is recommended that DOMSATS be implemented when the traffic model warrants.

TASK e

SUMMARY OF ENHANCEMENT REQUIREMENTS

- BASELINE NASA PAYLOAD CENTERS
  - GSFC, AUTOMATED EARTH ORBITING PAYLOADS
  - JPL, PLANETARY PAYLOADS
  - JSC, SPACELAB PAYLOADS
- STANDARD POC SYSTEM CONCEPT
- DATA BASE SUPERVISORY MANAGEMENT CONCEPT
- COMMUNICATION AND DATA ACQUISITION

TASK f

DEFINITION OF SYSTEM CONCEPTS

The objective of Task f is to define feasible, cost effective flight control options and develop guidelines for implementation of the options.

Since this task synthesizes the results of the preceding tasks, the results of this task effort in effect reflect the study results.

The results which will be discussed in detail in the following charts may be summarized as follows:

a) Three system concept options were selected and these options have been examined from the standpoint of their relation to the system command and control concepts and various aspects of their implementation.

b) The baseline system concept utilizes three payload Control Centers for STS Payloads, GSFC for Automated Earth Orbiting Payloads, JPL for Planetary Payloads and JSC for Spacelab Payloads. This concept primarily utilizes the existing capabilities of these three centers.

c) The Implementation guidelines include:

- A four phase approach to the satisfaction of the ultimate requiremnts
- An evolutionary approach involving a logical sequence of actions.
- The key decision points are brought to the attention of NASA.

TASK f

DEFINITION OF SYSTEM CONCEPTS

OBJECTIVE: DEFINE FEASIBLE, COST EFFECTIVE FLIGHT CONTROL OPTIONS AND DEVELOP IMPLEMENTATION GUIDELINES

SUMMARY OF TASK RESULTS:

- THREE SYSTEM CONCEPT OPTIONS EXAMINED
- BASELINE SYSTEM CONCEPT USES PRIMARILY EXISTING CAPABILITIES OF JSC, JPL, AND GSFC
- IMPLEMENTATION GUIDELINES INCLUDE:
  - 4 PHASE APPROACH TO SATISFACTION OF ULTIMATE REQUIREMENTS
  - EVOLUTIONARY APPROACH INVOLVING LOGICAL SEQUENCE
  - KEY DECISION POINTS ARE IDENTIFIED

TASK f

ALTERNATIVES FOR POC LOCATION

The adjacent chart shows the preliminary listing of POC alternatives for STS Payload Control Task b.

These alternatives were based on the following precepts:

1. Utilization of an existing single POC for each class of STS payloads; Automated Earth Orbiting, Planetary and Spacelab payloads, respectively.
2. The use of multiple POC's for each class of STS payload.
3. An alternative in which each NASA Payload Development Center has its own POC for flight control of its payloads.

This matrix of options was used as a point of departure for the development of system concepts in Task f.

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TASK f

ALTERNATIVES FOR POC LOCATIONS

MISSION TYPES	OPTIONS		
	1	2	3
AUTOMATED EARTH ORBIT	EXISTING SINGLE POC FOR ALL NASA EO AUTOMATED PAYLOADS GSFC JSC	MULTIPLE POC'S FOR NASA LEO AUTOMATED PAYLOADS GSFC / JSC GSFC / MSFC / ARC JSC / MSFC / GSFC	EACH DEVELOPMENT CENTER HAS A POC FOR ITS OWN PAYLOADS GSFC / MSFC / JSC / ARC / JPL
AUTOMATED PLANETARY	EXISTING SINGLE POC FOR ALL NASA PLANETARY PAYLOADS JPL ARC * * REMOTE POC FOR PIONEER	MULTIPLE POC'S FOR NASA PLANETARY PAYLOADS JPL / ARC	EACH DEVELOPMENT CENTER HAS A POC FOR ITS OWN PAYLOADS JPL / ARC / LaRC
SPACELAB	EXISTING SINGLE POC FOR ALL NASA SPACELAB PAYLOADS JSC JPL GSFC	MULTIPLE POC'S FOR NASA SPACELAB PAYLOADS JSC / MSFC JSC / JPL JSC / GSFC JSC / JPL / GSFC JSC / JPL / GSFC / MSFC	EACH DEVELOPMENT CENTER HAS A POC FOR ITS OWN PAYLOADS JSC / JPL / MSFC / GSFC / ARC / LaRC

TASK f

SEQUENTIAL FLOW OF SELECTION PROCESS FOR SYSTEM CONCEPTS

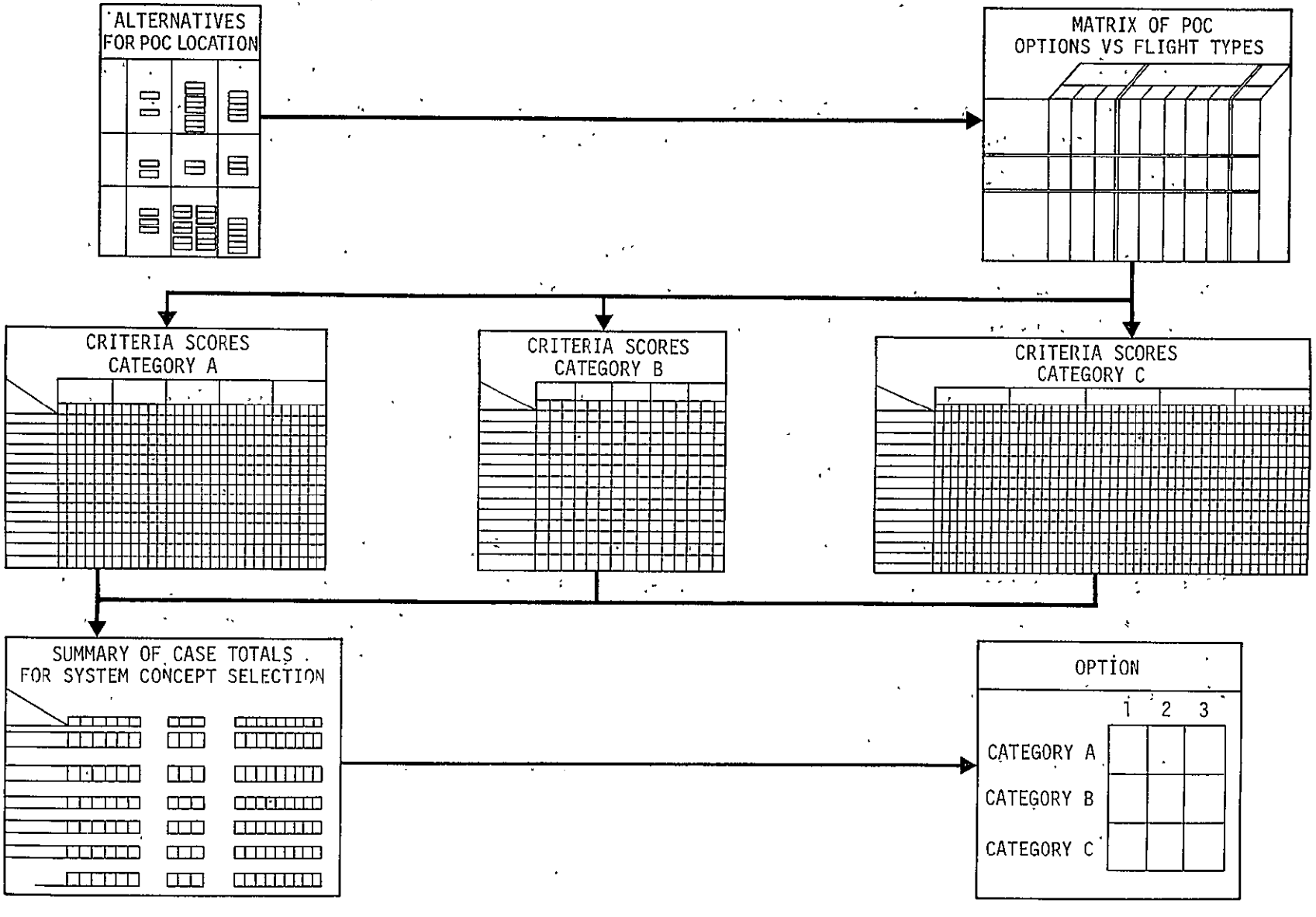
Beginning with the alternatives for POC location on the previous chart, the next step is to lay out the individual alternatives by flight type in a matrix and assign an individual alphanumeric designator to each separate alternative or case.

Following this, each case is evaluated in a matrix which assesses each applicable system element against each selection criteria for each of the flight type categories; A, B and C.

In the next matrix the scores are summed for each system element under each payload class and the three highest figures of merit for each payload class are entered in the columns of the next matrix under Options 1, 2 and 3 in descending order of magnitude.

TASK f

SEQUENTIAL FLOW OF SELECTION PROCESS FOR SYSTEM CONCEPTS



TASK f

SELECTION CRITERIA FOR SYSTEM CONCEPT OPTIONS

An initial list of 14 candidate criteria was circulated for comment by study representatives of the NASA Centers. Through the coordination cycle, the list was refined and because of the problem of overlapping criteria, was reduced to three basic criteria containing a total of seven factors as noted on the chart on the facing page.

These criteria do not apply to all system elements of all cases evaluated; therefore, the Task f report contains a matrix of applicability which was used as a guide to the application of these criteria in the evaluation process.

Cost Factors are applicable to either recurring or non-recurring type costs. Due to the nature of the system element being evaluated, both recurring and non-recurring costs do not apply to the same element simultaneously.

Operational effectiveness includes a factor entitled "Factors to Enhance Crew Safety." It is recognized that crew safety is an STS operator function. However, various system concepts for payload support can affect the integrity of the integrated STS/STS Payload Operations Plan and thus indirectly affect crew safety. A highly integrated organization for payload operations will normally enhance crew safety considerations.

Responsiveness to users is principally a function of how accessible the system for payload operations can be made to the users and the accessibility of engineering support to the real time operation of the user's payloads.

TASK f

SELECTION CRITERIA FOR SYSTEM CONCEPT OPTIONS

- COST FACTORS
  - NON-RECURRING
  - RECURRING
- OPERATIONAL EFFECTIVENESS
  - COMPLEXITY OF INTERFACES
  - FACTORS TO ENHANCE CREW SAFETY
  - FACILITY LOADING EFFICIENCY
- RESPONSIVENESS TO USERS
  - ACCESSIBILITY OR UTILITY TO USERS
  - ACCESSIBILITY TO ENGINEERING SUPPORT

TASK f

DATA IN SUPPORT OF CONCEPT SELECTION

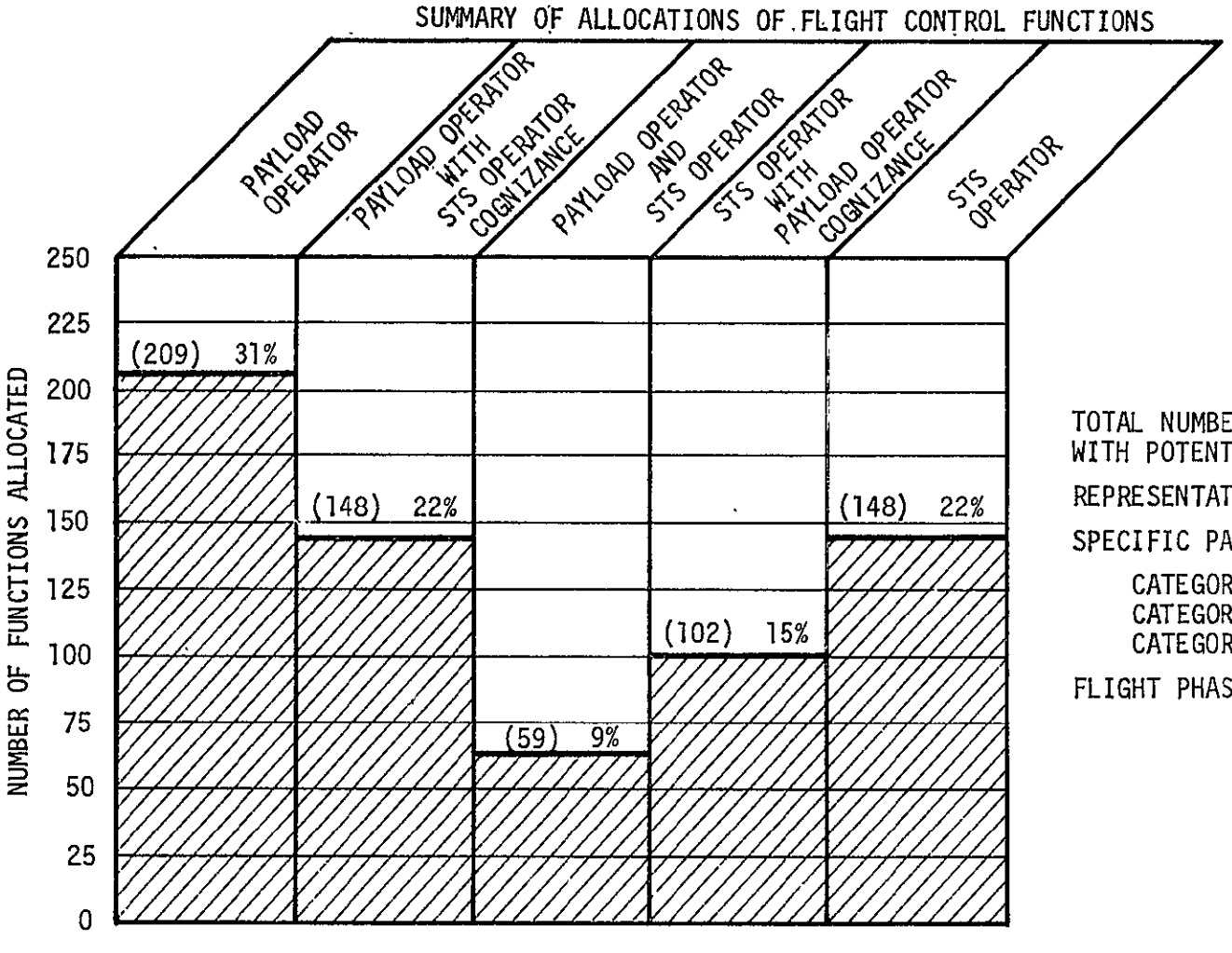
Concept selection considers the results of the other study tasks. One of the significant inputs to the selection of system concepts is the analysis of Task d allocations of flight control ground functions.

The facing chart shows the distribution of allocations for 666 flight control ground functions. Selection of flight control ground functions emphasized the integrated flight plan so as to include as nearly a complete set of functions requiring the attention of the STS Operator as possible. There may be additional functions carried out solely by the Payload Control Centers during free flight phases which are not necessarily listed among the functions which were allocated.

Of the functions which were analyzed, approximately 70% require the attention of the STS operator in one way or another. This is the primary reason for the recommendation in the system command and control concept, for use of an STS Payload Integrated Operations Manager to support the payload operational interfaces with the STS Operator.

TASK f

DATA IN SUPPORT OF CONCEPT SELECTION



TOTAL NUMBER OF FUNCTIONS WITH POTENTIAL STS INTERFACES - - - 666

REPRESENTATIVE FLIGHT TYPES - - - - 14

SPECIFIC PAYLOADS/DISCIPLINES - - - 24

- CATEGORY A - 15
- CATEGORY B - 2
- CATEGORY C - 7

FLIGHT PHASES CONSIDERED - - - - - 15

TASK f

DATA IN SUPPORT OF CONCEPT SELECTION (CONTINUED)

The next two charts contain a listing of the 14 flight types with 3 additional variations on types L, M, and N. The charts show the duration and number of overlaps encountered each year for each flight type.

Summing the overlaps of all flights in each year provides the basis for the chart which follows, "Analysis of Traffic Model and Flight Overlaps."

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TASK f

DATA IN SUPPORT OF CONCEPT SELECTION

DURATION OF STS PAYLOAD OPERATIONS SHOWING OVERLAPS

PAYLOAD FLIGHT TYPE AND DURATION	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
A SPACELAB MODULE AND PALLET -- ATL 7-30 DAYS						NO OVERLAP						
A SPACELAB MODULE AND PALLET – AMPS 7-30 DAYS						NO OVERLAP						
C SPACELAB PALLET ONLY, SO /-30 DAYS						NO OVERLAP						
C SPACELAB PALLET ONLY -- STELLAR 7-30 DAYS						NO OVERLAP						
B SPACELAB MODULE AND PALLET MULTI-DISCIPLINE 7-30 DAYS	◄					NO OVERLAP					(2)*	(2)*
D SPACELAB, PALLET ONLY, MULTI DISCIPLINE 7-30 DAYS						NO OVERLAP						
J SPACELAB MODULE ONLY, DEDICATED DISCIPLINE L S 7-30 DAYS						NO OVERLAP						
J MULTI-CARGO DELIVERY – EXPLORER/ STP 2 YEARS												

*ASSUME 6 SHUTTLE FLIGHTS PER YEAR WITH NO OVERLAP, HOWEVER 2 OVERLAPPING PL OPERATIONS DUE TO 7 FLIGHTS IN 1990 AND 8 FLIGHTS IN 1991

TASK f

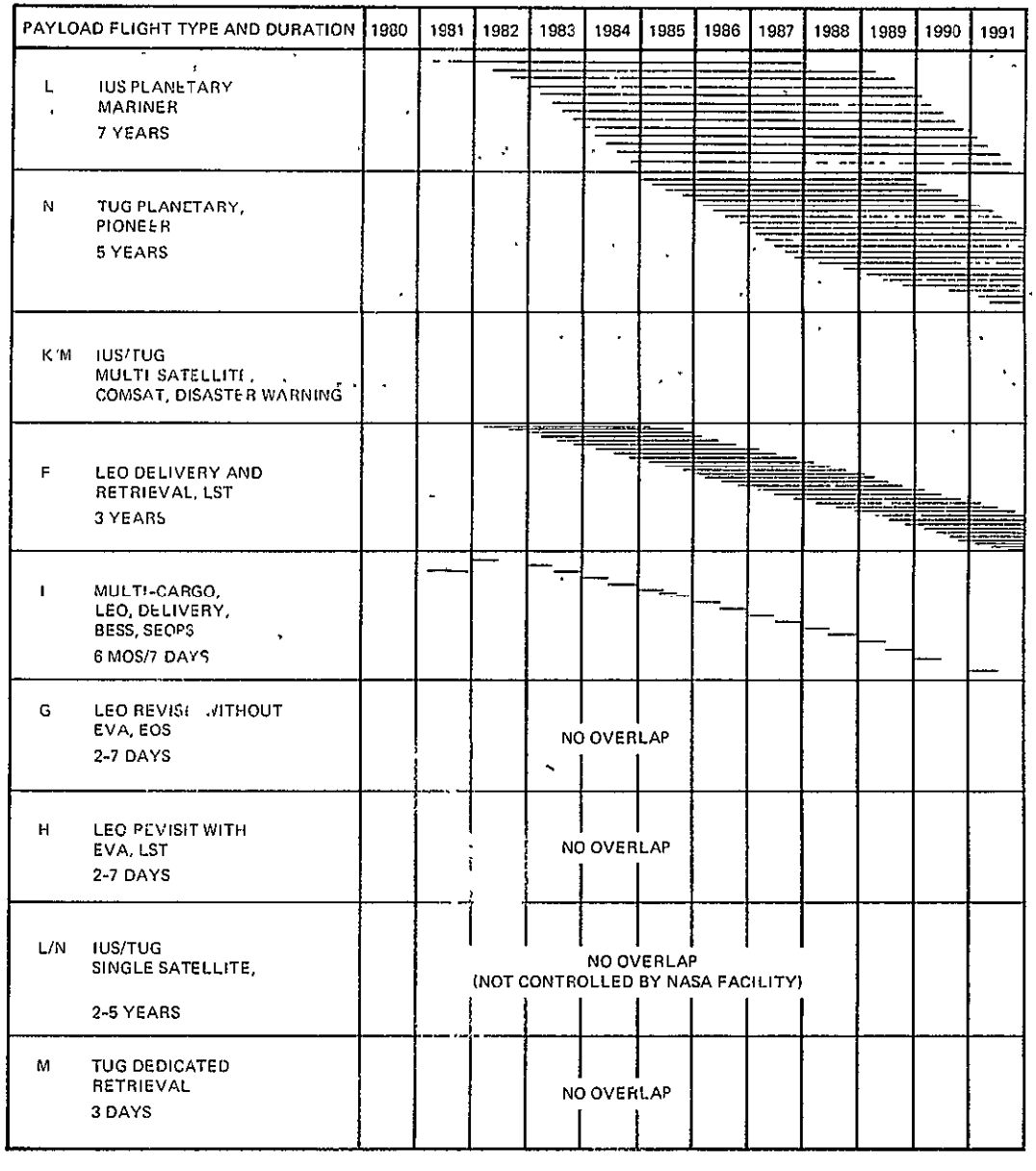
DATA IN SUPPORT OF CONCEPT SELECTION (CONTINUED)

(Continued from previous page)

TASK f

DATA IN SUPPORT OF CONCEPT SELECTION (CONTINUED)

DURATION OF STS OPERATIONS SHOWING OVERLAPS (CONTINUED)



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TASK f

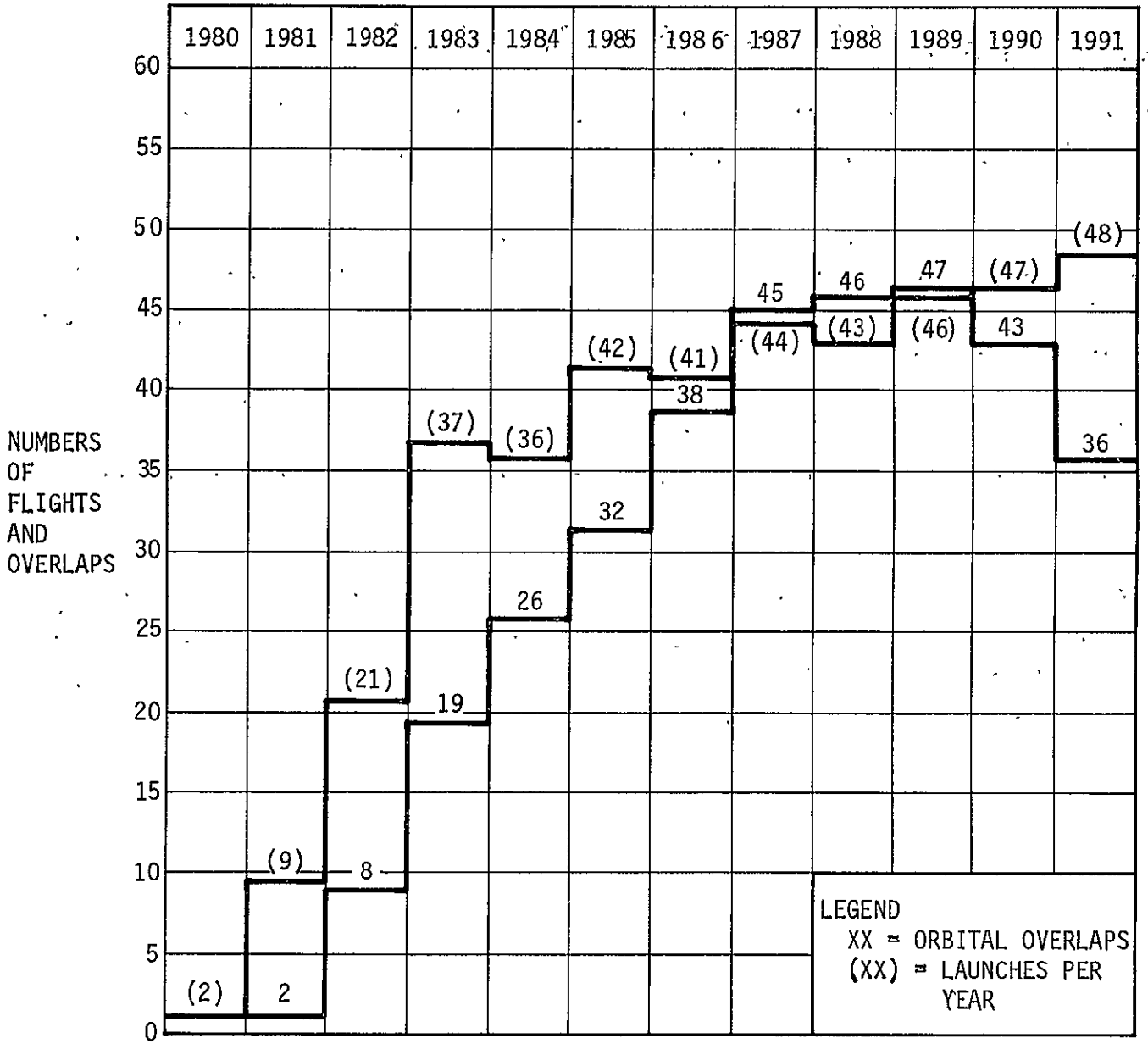
DATA IN SUPPORT OF CONCEPT SELECTION (CONTINUED)

The two graphic plots on the facing page show the number of STS payload flights per year taken from the study traffic model and the number of payload reference flight types which overlap in duration (shown in the shaded area).

It can be seen that the major load imposed on the payload support capabilities by the overlap of long duration flights lags the build-up of launches by approximately 2 years. The number of long duration flights by complex payloads which occur simultaneously is as important an indication of the workload placed on payload supporting resources as the frequency of launches.

TASK f

DATA IN SUPPORT OF CONCEPT SELECTION
ANALYSIS OF TRAFFIC MODEL AND FLIGHT OVERLAPS



TASK f

SYSTEM CONCEPT OPTIONS SELECTED

This chart shows the system concept options finally selected as a basis for further evaluation of STS payload support requirements.

Option 1 (baseline system) utilizes the extant capabilities of GSFC, JPL and JSC for control of the three classes of payloads historically supported by those centers. NASA/ARC is shown as the POC for Pioneer spacecraft since it currently provides a remote control center with established interfaces with the JPL SFOF and the DSN.

In Option 2 concept the support of Automated Earth Orbiter Payloads has been extended to include JSC and the operational loads imposed by an increase in spacelab flights is supported by GSFC.

Option 3 considers a philosophy in which all Payload POCC's would be standard and any POCC could support any payload with quick turn-a-round times for reconfiguration. In this concept a portable combined DOMSAT Terminal/POCC would support operations from other NASA development Centers or remote users as an extension of an existing POC.

TASK f

SYSTEM CONCEPT OPTIONS SELECTED

	OPTIONS 1	2	3
AUTOMATED EARTH ORBITING PAYLOADS	GSFC	GSFC/JSC	GSFC JPL JSC ↓ *
PLANETARY PAYLOADS	JPL - ARC	JPL - ARC	
SPACELAB PAYLOADS	JSC	JSC/GSFC	

*STANDARD POCC's SUPPORT ANY TYPE PAYLOAD WITH PORTABLE DOMSAT TERMS/POCC's FOR USE AT OTHER CENTERS.

TASK f

CONFIGURATION OF SYSTEM ELEMENTS - CONCEPT NO. 1

The configuration in this concept includes the three Centers for prime control of the three payload classes and the remote POCC for Pioneer at ARC. All POC's are tied into the launch and landing sites, the MCC-H, and the data acquisition facilities via the NASCOM net. The DOD Satellite Test Center can communicate with NASA POC's and the MCC-H for handover operations when necessary.

Each of the POC's in the baseline system include functional capabilities, as follows:

1. Ground Communications
2. Tracking data analysis and orbit determination
3. Information processing
4. Payload science and engineering analysis
5. A data base system
6. One or more POCC's.

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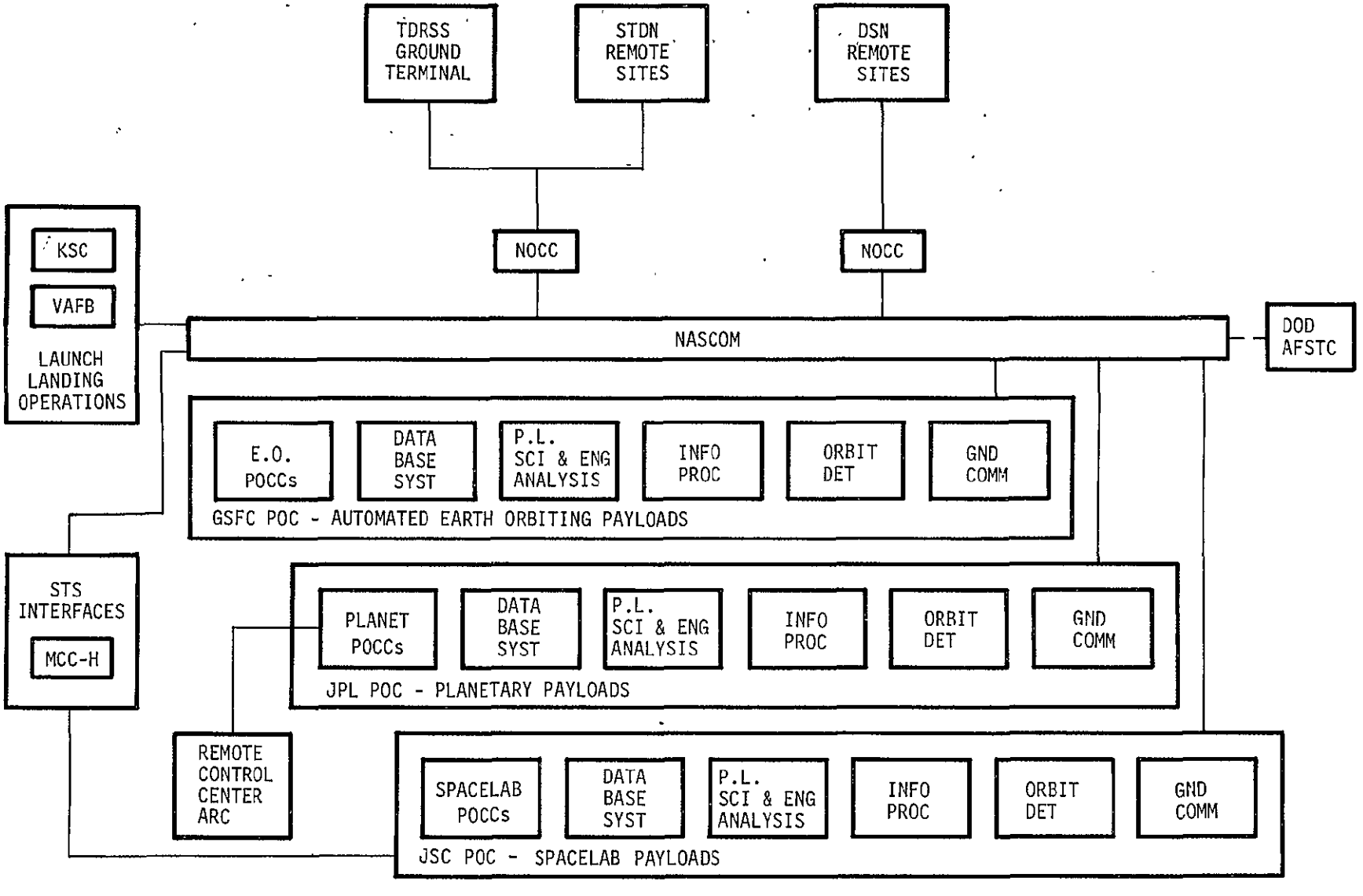
TASK f

CONFIGURATION OF SYSTEM ELEMENTS - CONCEPT NO. 1



TASK f

CONFIGURATION OF SYSTEM ELEMENTS - CONCEPT NO. 2

This configuration shows the dual purpose configurations for GSFC and JSC as they expand their capabilities to support both Automated Earth Orbiting and Spacelab Payloads.

In this configuration a payload coordinator for each class of payload has been added to coordinate all payloads of a given class between centers and provide the interface for his class of payloads with the MCC-H.

Planetary Payload orbit determination is shown as a separate function at JPL.

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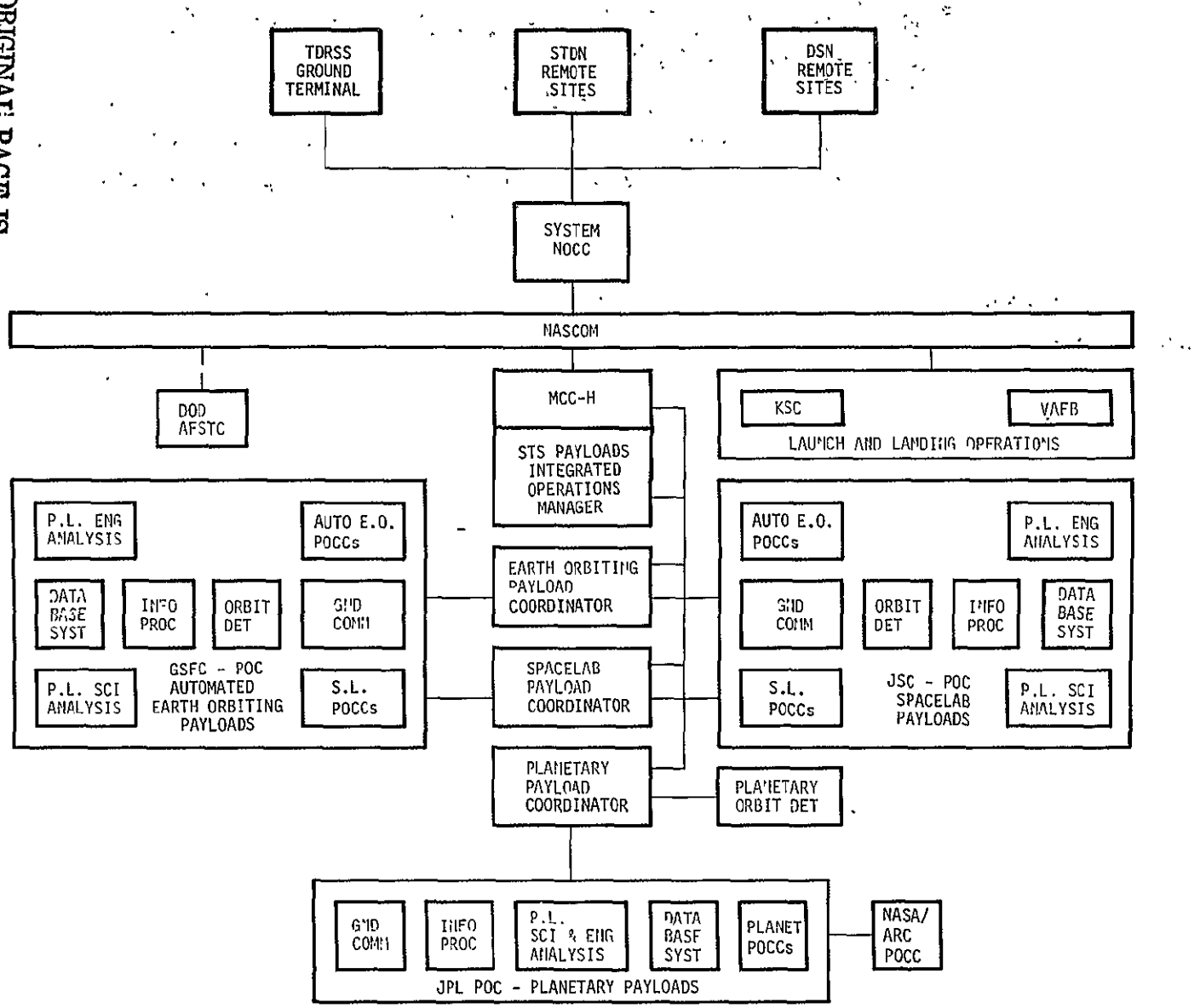
TASK f

CONFIGURATION OF SYSTEM ELEMENTS, CONCEPT NO. 2



TASK f

CONFIGURATION OF SYSTEM ELEMENTS - CONCEPT NO. 3

This configuration depicts the arrangement of system elements for the concept involving a NASA-wide integrated system of standard POCC's. Each POC works through a payload coordinator for a given class of payloads in interfacing with either the MCC-H or portable remote DOMSAT TERMINAL/POCC's.

This concept will be explained in further detail later under the command and control concept discussion.

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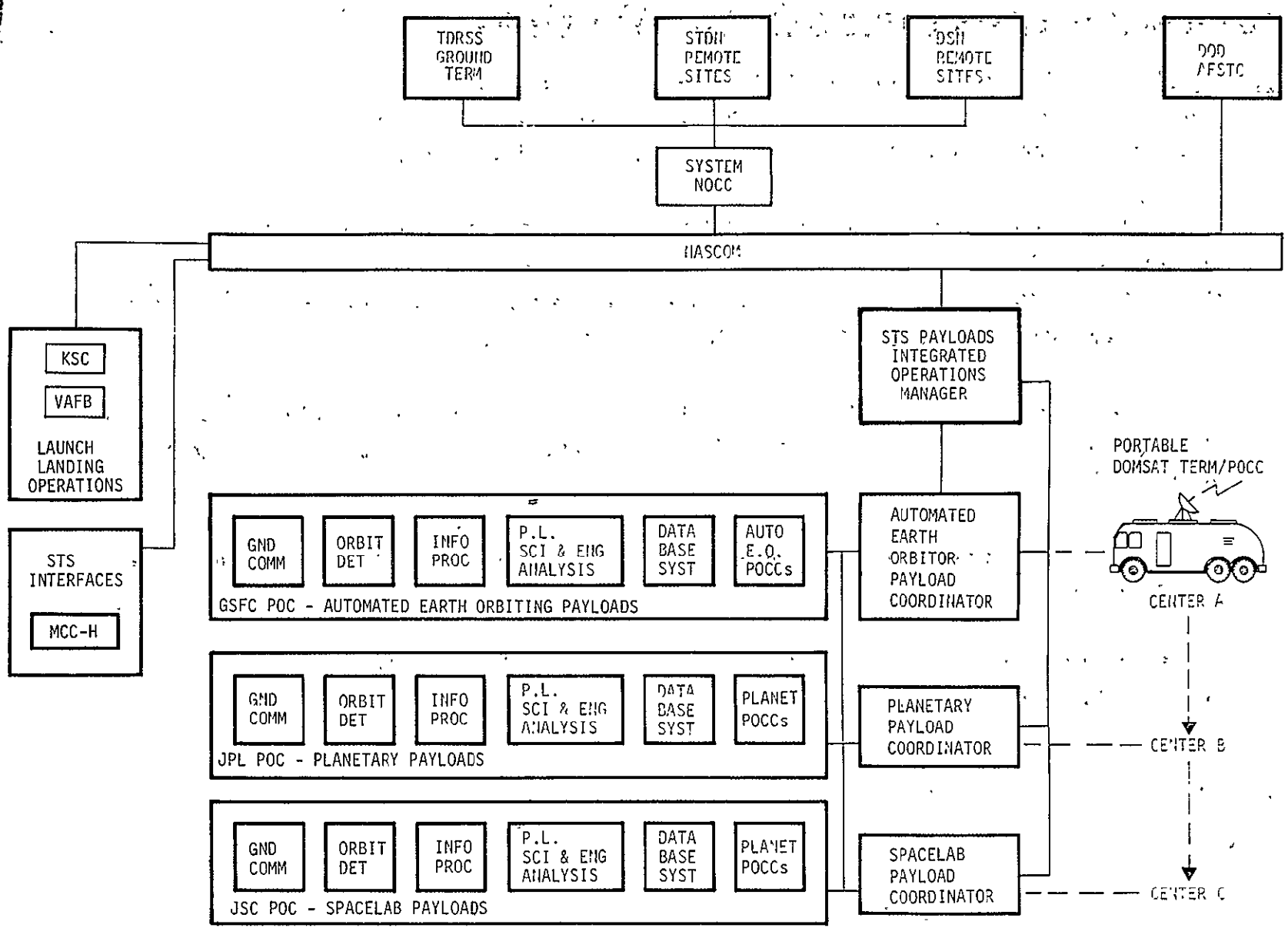
TASK f

CONFIGURATION OF SYSTEM ELEMENTS, CONCEPT NO. 3



TASK f

COMMAND AND CONTROL CONCEPT NO. 1

This chart shows the command and control concept recommended for the baseline system concept. The solid lines on the chart indicate command and control channels. The dashed lines are information channels used during launch and landing operations.

An Integrated Operations Manager (IOM) provides a standard interface between the MCC-H and Payload Coordinators for the three classes of payloads. NASA Headquarters obtains payload operational status from and passes policy information through the Integrated Operations Manager on all matters requiring attention at that level.

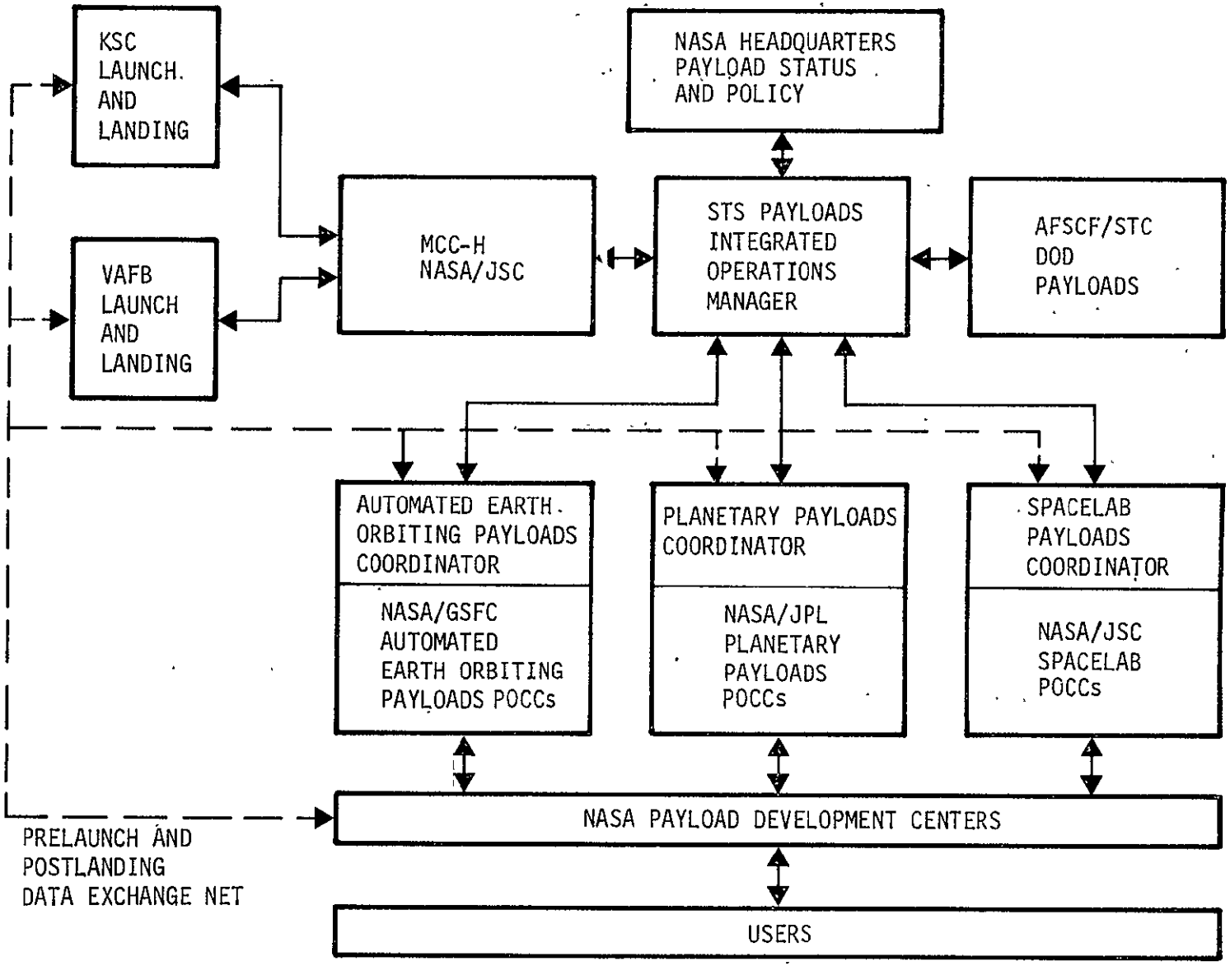
The Payload Coordinator (PC) for each class of payloads coordinates matters between all POCC's supporting a given class of payloads and presents a standard interface between the POCC's and the IOM.

POCC's act as agents for both the user and the NASA Development Centers for real time operational matters.

Users may work closely with POCC's through the use of host facilities to interface with the operational environment.

TASK f

COMMAND AND CONTROL CONCEPT NO. 1



TASK f

COMMAND AND CONTROL CONCEPT NO. 2

This concept for command and control applies to either system Configuration No. 2 or 3.

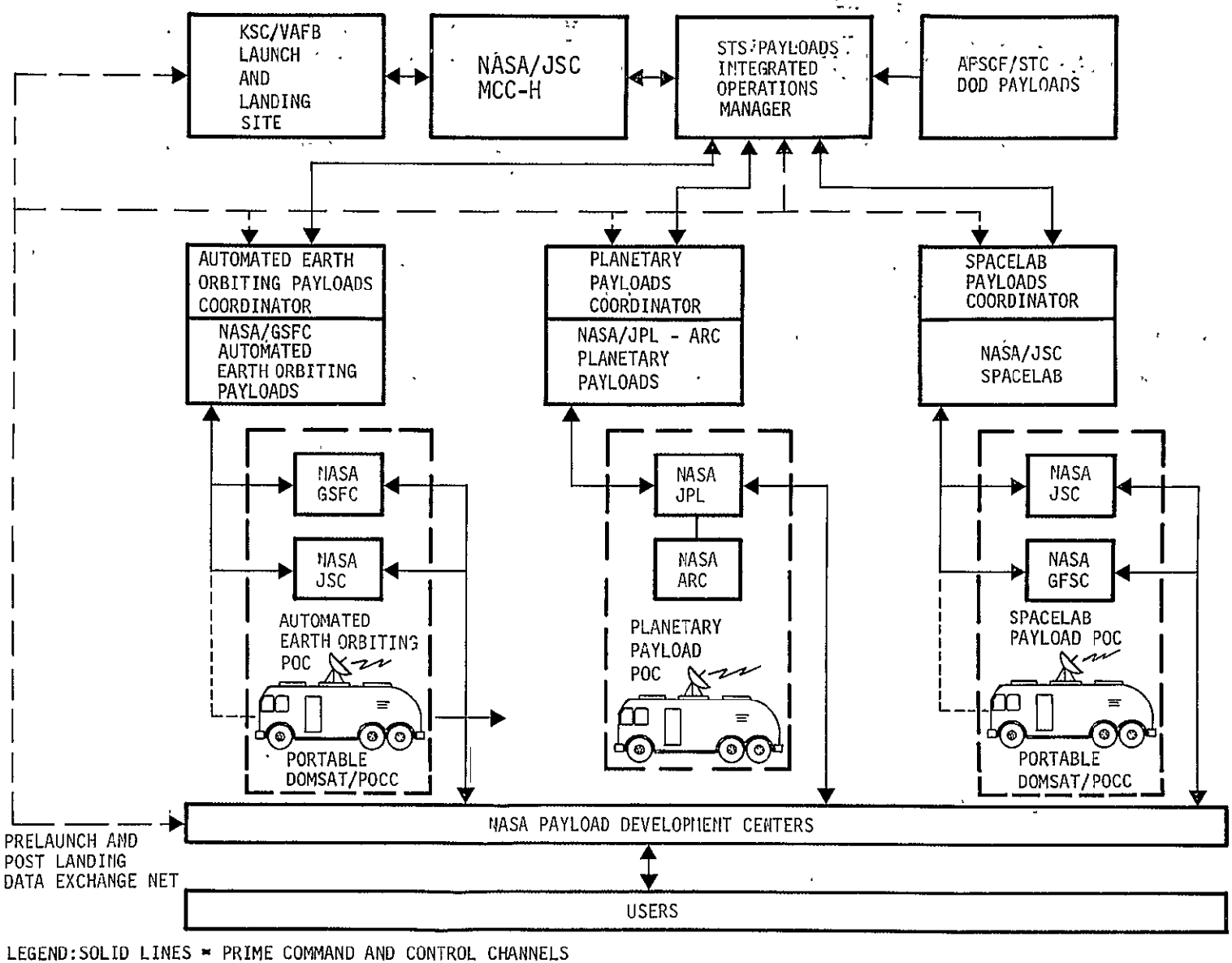
The function of the Integrated Operations Manager (IOM) is the same as for Concept No. 1. The Payload Coordinators (PC) functions are expanded in this command and control concept to include not only the coordination of POCC's within a NASA Center but to include all Centers and all remote portable DOMSAT TERM/POCC's utilized to support a class of payloads.

This concept functions in an environment where all POCC's are standard and can support any class of payload. This places an increased burden on the PC to be responsible for all unique aspects of an operation for a particular class of payloads.

The portable remote DOMSAT TERM/POCC will have the capability to function as a standard POCC drawing additional support from the lead NASA POC for the appropriate class of payloads. Although Payload Commands may be generated at the portable POCC, they must be checked and enabled by the parent POC and/or the MCC prior to being transmitted to a payload.

TASK f

COMMAND AND CONTROL CONCEPT NO. 2



LEGEND: SOLID LINES = PRIME COMMAND AND CONTROL CHANNELS
DASHED LINES = LAUNCH AND LANDING INFORMATION NET

TASK f

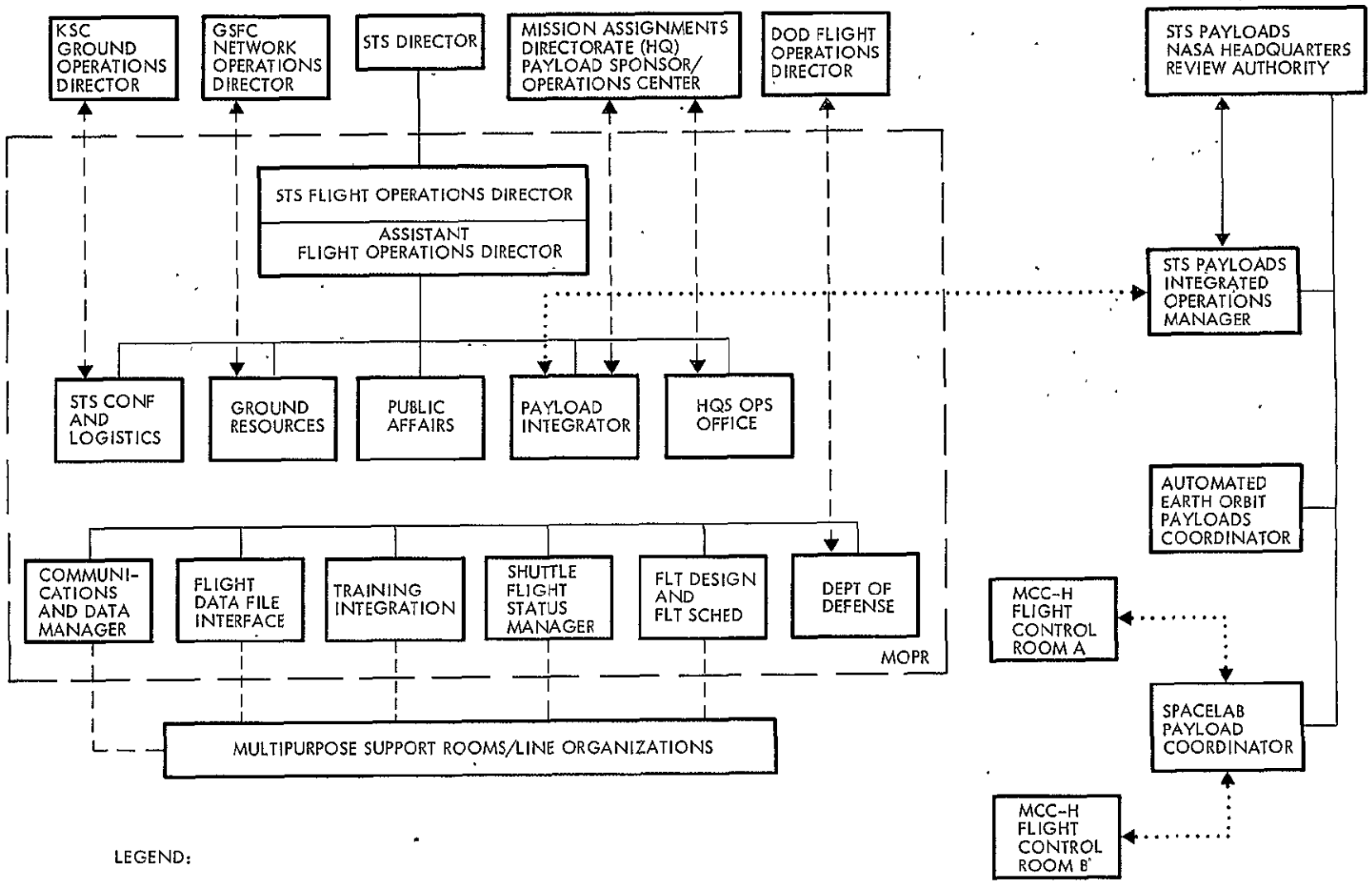
STS PAYLOAD OPERATIONAL INTERFACES WITH THE STS OPERATOR AT THE MCC-H

The facing block diagram shows the organization of the STS Operator team in the Mission Operations Planning Room (MOPR).

The dotted lines show the interfaces between the STS Payload Integrated Operations Manager (IOM) and the Payload Integrator for MOPR and between the Spacelab Payload Coordinator and the Flight Control Rooms at MCC-H. Another alternative would be for the IOM and the Payload Integrator to merge their functions into a single function.

TASK f

STS PAYLOAD OPERATIONAL INTERFACES WITH STS OPERATOR AT THE MCC-H



TASK f

LOGICAL COMBINATIONS OF PAYLOAD SUPPORT FUNCTIONS

Once a three level hierarchy is considered for payload command and control, various functions may be performed optionally at one or more of the levels.

For example, the command and control concept involves a flight director within a POCC, a Payload Coordinator for all payloads of a single class at the POC and an Integrated Operations Manager for coordination of payload operations of all classes. This organization provides fertile ground for a number of trade-offs relative to what functions should be optimally combined at the various levels for the most cost-effective operation. The next two charts provide a list of some of the functions and some tentative recommendations. This subject should be studied in more detail than was possible during this study.

TASK f

LOGICAL COMBINATIONS OF PAYLOAD SUPPORT FUNCTIONS

	FUNCTIONS WHICH CAN BE COMBINED FOR ALL CLASSES OF PAYLOADS	FUNCTIONS WHICH CAN BE COMBINED FOR ALL PAYLOADS OF A CLASS	FUNCTIONS WHICH MUST RESIDE AT EACH POC
1. PAYLOAD COMMAND ACTIVITIES			X
2. TRACKING DATA ANALYSIS AND ORBIT DETERMINATION		X	
3. PREPROCESSING OF TELEMETRY DATA AT ACQUISITION SITE	X	X	
4. PREPARATION OF USER DATA TAPES			X
5. PROCESSING AND DISPLAY OF REAL TIME TELEMETRY			X
6. REAL TIME SIMULATIONS			X
7. ATTITUDE DETERMINATION AND POINTING			X
8. PROCESSING OF WIDE BAND DATA AND VIDEO ENHANCEMENT	X	X	
9. SCIENCE PAYLOAD SUPPORT OF REAL TIME OPERATION			X
10. ENGINEERING PAYLOAD SUPPORT AND CONTINGENCY ANALYSIS			X
11. CONSUMABLES MONITORING			X

TASK f

LOGICAL COMBINATIONS OF PAYLOAD SUPPORT FUNCTIONS (CONTINUED)

(Continued from previous page)

LOGICAL COMBINATIONS OF PAYLOAD SUPPORT FUNCTIONS (CONTINUED)

		FUNCTIONS WHICH CAN BE COMBINED FOR ALL CLASSES OF PAYLOADS	FUNCTIONS WHICH CAN BE COMBINED FOR ALL PAYLOADS OF A CLASS	FUNCTIONS WHICH MUST RESIDE AT EACH POC
12.	MAINTENANCE OF OPERATIONAL INTERFACES WITH LAUNCH FACILITY		X	X
13.	OPERATIONS SCHEDULING AND REAL TIME REPLANNING		X	X
14.	DATA BASE MANAGEMENT, STORAGE AND RETRIEVAL		X	X
15.	GROUND COMMUNICATIONS, SWITCHING, ROUTING, DATA LOGGING, ERROR CORRECTION, ETC.	X		
16.	NETWORK CONTROL, AND SCHEDULING	X		
17.	OPERATIONAL USER LIAISON			X
18.	OPERATIONAL INTERFACE BETWEEN PAYLOAD OPERATOR AND STS OPERATOR	X	X	
19.	COMPUTER PROGRAMMING SUPPORT AND MAINTENANCE		X	X
20.	ADMINISTRATIVE SUPPORT	X	X	X
21.	FACILITY AND EQUIPMENT MAINTENANCE	X	X	X

TASK f

COMMUNICATIONS ELEMENT

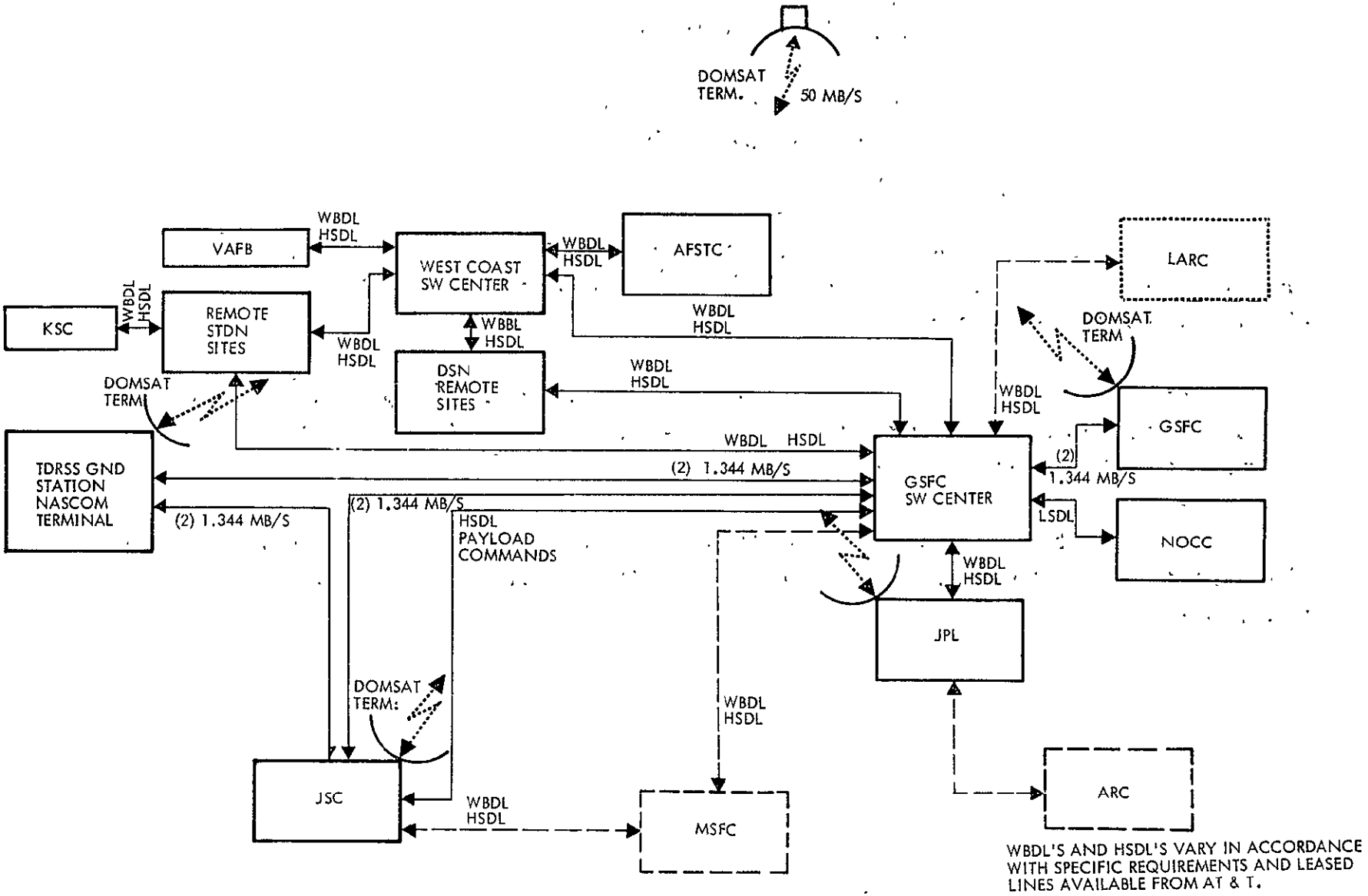
One of the five elements used to define a system concept for STS Payload Operations is the communications element.

The diagram on the facing page contains in the solid lines the basic communications resources required for the baseline system.

The dashed lines show the additional POC's that might be utilized in the control of STS payloads through the use of standard portable POCC's working through DOMSAT terminals at each of the three baseline POC's.

TASK f

COMMUNICATIONS ELEMENTS OF SYSTEM CONCEPTS



TASK f

OPERATIONAL TEAM STRUCTURES FOR REAL TIME

The command and control concepts for STS payloads require the operational team structures for the real time operation that are shown on the facing page.

The Launch support team consists primarily of personnel from the payload contractor's integration and test crew. This team has an operational interface with the POCC during the prelaunch and launch activities at KSC or VAFB.

The Payload Class Coordinator is resident at each of the lead centers for a class of payloads. His team is responsible for coordinating the operation of all POCC's in support of his assigned payload class.

The Integrated Operations Manager coordinates the overall STS payload operational activities with the STS Operator. In addition, he maintains the interface with NASA Headquarters for real time payload operational matters.

The functions of the POCC teams are similar to existing organizations for payload operations except that network liaison may be a more appropriate function of the Payload Class Coordinator.

TASK f

OPERATIONAL TEAM STRUCTURES FOR REAL TIME OPERATIONS

- PAYLOAD LAUNCH SUPPORT TEAM
- PAYLOAD CLASS COORDINATOR
- INTEGRATED OPERATIONS MANAGER
- POCC TEAMS
  - OPERATIONS DIRECTOR
  - COMMUNICATIONS AND DATA
  - NETWORK LIAISON*
  - ORBIT DETERMINATION
  - DATA BASE MANAGEMENT
  - SPACE SCIENCE SUPPORT TEAM
  - PAYLOAD ENGINEERING SUPPORT TEAM
  - DATA PROCESSING SUPPORT TEAM
  - TRAINING AND SIMULATION

*THIS FUNCTION MAY BE PERFORMED BY PAYLOAD CLASS COORDINATOR

TASK f

DRIVERS FOR SYSTEM IMPLEMENTATION

The five major drivers for system implementation as listed on the facing pages are:

1.	Cost	Minimum cost dictates the use of existing facilities for as long as possible. Cost will also be minimized by standardization and as new systems are phased in, standardization can be achieved.
2.	Flight Rate Build-Up	As the traffic model builds toward peak levels the system capabilities should expand to accommodate the load. Based on the traffic model, the logical time phased support capability would seem to be 1980 for the initial capability, 1983 for an incremental enhancement and 1986 for the final system capability.
3.	Increasing Numbers of Flight Overlaps	Most flight overlaps occur with Planetary and Large complex free flyer payloads. As overlaps build up the requirements on data handling capacity, computation capacity and team structures will increase. Data compression or filtering at the source should be considered as a means of constraining the ultimate system capacities.
4.	Common Payload Interfaces With MCC-H	The focal point during certain flight phases for an increasing number of operational functions will be the interface with MCC-H. Simplification and standardization of interfaces and operating procedures will minimize this impact.
5.	Accommodation of Spacelab Payloads	Spacelab payloads will be the largest single class of payloads to be accommodated. Since these payloads are all short duration (7-30 days), the POCC systems at the various centers should be capable of spacelab payload support with quick turn-a-round times. Standard POCC's would facilitate this concept.

TASK f

DRIVERS FOR SYSTEM IMPLEMENTATION

• COST	DRIVES TOWARD USE OF EXISTING CAPABILITIES, STANDARDIZATION OF SYSTEMS AND PROCEDURES; SYSTEM VERSATILITY.
• FLIGHT RATE BUILD-UP	SUGGESTS TIME PHASED IMPLEMENTATION; IMPROVED SYSTEM TURN-A-ROUND TIMES; ENHANCED DATA HANDLING CAPABILITIES.
• INCREASING NUMBERS OF FLIGHT OVERLAPS	CONSIDERATION FOR MULTIPLE RESOURCES FOR DATA HANDLING, COMPUTATION, TEAM STRUCTURES; ULTIMATELY FOR DATA COMPRESSION/FILTERING AT SOURCES.
• COMMON PAYLOAD INTERFACES WITH MCC-H	DRIVES TOWARD STANDARD OPERATING INTERFACES AND PROCEDURES.
• ACCOMMODATION OF SPACELAB PAYLOADS	SPACELAB PAYLOADS TO BE LARGEST SINGLE CLASS, ALL SHORT DURATION. ALL POCC'S SHOULD BE STANDARD AND CAPABLE OF SPACELAB PAYLOAD SUPPORT.

TASK f

IMPLEMENTATION RECOMMENDATIONS

Based on the implementation drivers previously listed, a four phased approach is recommended. The ultimate system for STS payload support is a fully integrated, standardized, multi-center NASA-wide system. Cost is the major driver for such a system. With a relatively constant NASA budget and with steadily increasing requirements coupled with continued inflation, improved efficiency is the only solution.

TRW recommends that the following areas be explored as potential ways to improve efficiency and reduce costs.

a. Standardized payload data and command formats and multiplexing schemes, standard operational procedures and system interfaces.

b. Integration of NASA payload support resources into an overall NASA-wide system.

c. An evolutionary,time phased building block approach to phase in new capabilities just ahead of the requirements stemming from increased loads on the system.

d. The GSFC POCCNET concept should be investigated for applicability to all payload centers and the feasibility of extending the concept to include a capability for netting the resources of the various centers together in a common network should be explored.

e. Improving POCC utilization through standardization and rapid reconfiguration capability.

TASK f

IMPLEMENTATION RECOMMENDATIONS

- A FOUR PHASED EVOLUTIONARY APPROACH IS RECOMMENDED FOR AN INTEGRATED, MULTI-CENTER NASA-WIDE SYSTEM FOR STS PAYLOAD SUPPORT.
  - COST IS MAJOR DRIVER. WITH CONSTANT NASA BUDGET COUPLED WITH INCREASING REQUIREMENTS AND CONTINUED INFLATION, IMPROVED SYSTEM EFFICIENCY IS ONLY SOLUTION.
- RECOMMENDED AREAS FOR EXPLORATION LEADING TO IMPROVED SYSTEM EFFICIENCY ARE:
  - STANDARDIZATION OF PAYLOAD DATA FORMATS, SYSTEM INTERFACES AND OPERATING PROCEDURES.
  - INTEGRATION OF NASA PAYLOAD SUPPORT RESOURCES INTO NASA-WIDE SYSTEM.
  - A TIME PHASED BUILDING BLOCK APPROACH WHICH BUILDS CAPABILITIES JUST AHEAD OF REQUIREMENTS. BASED ON EXISTING CAPABILITIES OF CENTERS FOR INITIAL FLIGHT PHASE.
  - EXTEND THE GSFC POCCNET CONCEPT TO ALL CENTERS WITH PAYLOAD CAPABILITY AND EXTRAPOLATE INTO A NASA-WIDE INTEGRATED SYSTEM.
  - IMPROVE POCC UTILIZATION FACTOR. STANDARD POCC'S WOULD SUPPORT ANY PAYLOAD ON SHORT TURN-A-ROUND BASIS.

TASK f

PHASED IMPLEMENTATION APPROACH

Phase I extends from 1976 to 1980. During this period the requirements should be defined for the ultimate system for STS payload support and implementation planning should be completed along with the scheduling of enhancements required to evolve from the baseline system to the ultimate system in a logical building block approach. The studies identified on the opposite page should be completed in order to confirm the feasibility of a fully integrated NASA-wide approach to STS payload support and to provide a basis for implementing the various system enhancements.

A major effort to be completed during Phase I is the design and implementation of a POCC system to support Spacelab payloads.

In order to insure the capability to support initial phase II STS payloads of the Planetary and Automated Earth Orbiting types, the existing plans for enhancement of the GSFC and JPL POCC capabilities and communications systems to support TDRSS should be completed.

The lead times for introducing design standards into payloads are necessarily long. Therefore, the definition of standards should begin early and they should be introduced at the earliest practical time in order to be effective during phase III and IV.

TASK f

PHASED IMPLEMENTATION APPROACH

PHASE I - 1976 TO 1980 - REQUIREMENTS DEFINITION - IMPLEMENTATION OF BASELINE SYSTEM

- COMPLETE STUDIES TO DEFINE NASA-WIDE STS PAYLOAD SYSTEM INTEGRATION AND IMPLEMENTATION APPROACH.
  - REFINE PAYLOAD REQUIREMENTS FOR LONG RANGE SUPPORT
  - DEFINE PAYLOAD STANDARDS FOR COMMUNICATIONS, DATA FORMATS, COMMAND SYSTEMS, POCC'S.
  - TECHNOLOGY ASSESSMENT STUDIES - STANDARD FIRMWARE TO REPLACE SOFTWARE.
  - DEFINE HOST FACILITIES TO PROVIDE STANDARD USER SUPPORT FUNCTIONS AND INTERFACES.
  - INVESTIGATE IMPLEMENTATION OF PORTABLE REMOTE POCC OR DATA MONITORING FACILITY WITH DOMSAT TERMINAL.
  - MAKE TRADE-OFFS FOR EXPANSION OF THREE CENTER BASELINE SYSTEM CAPABILITIES VS ADDITIONAL CENTERS AS PAYLOAD OPERATIONS CENTERS.
  - DETERMINE IMPLEMENTATION APPROACH FOR STANDARD DATA TRANSFER CAPABILITY BETWEEN CENTERS.
  - DEFINE A SUPERVISORY CENTER WIDE DATA BASE MANAGEMENT SYSTEM FOR PAYLOAD OPERATIONS.
  - DEFINE A STANDARD POCC WITH QUICK TURN-A-ROUND CAPABILITY.
  - ESTABLISH STANDARDS AND REQUIREMENTS FOR DATA COMPRESSION FOR LONG TERM HIGH DATA RATE PAYLOADS.
- DESIGN AND IMPLEMENT SPACELAB POCC CAPABILITIES.
- AUGMENT BASELINE CENTERS FOR PAYLOAD SUPPORT IN ACCORDANCE WITH EXISTING PLANS FOR SUPPORT OF PHASE II PAYLOADS. THIS INCLUDES TDRSS GROUND COMMUNICATION SUPPORT CAPABILITY.
- BEGIN INTRODUCING STS PAYLOAD STANDARDS TO BE EFFECTIVE IN PHASE III AND IV.

TASK f

PHASED IMPLEMENTATION APPROACH

Phase II extends from 1980 to 1983. During 1983 the flight traffic model for STS payload launches increases from 44 to 77 percent of the total peak traffic. In addition, flight overlaps more than double with an increase from 8 to 19 during 1983. This buildup in launches and flight overlaps during 1983 indicates a significant increase in ground support activity levels and thus appears to be the logical break point for phasing in additional enhancements for use during phase III. Enhancements recommended for phase II in support of phase III should be fully operational no later than mid 1983. The additions recommended for implementation during phase II include the items on the adjacent page.

The STS payloads launched prior to 1983 should be adequately supported by an augmented existing capability with the addition of a POCC system for Spacelab payloads. The timing for installation of a DOMSAT terminal at the Payload Control Centers will depend upon the communications traffic analysis for the various system nodes. Some centers may require DOMSAT communications or other wideband ground link enhancements to be operational during phase II.

TASK f

PHASED IMPLEMENTATION APPROACH

PHASE II — 1980 TO 1983 — BASELINE SYSTEM — AUGMENTED EXISTING CAPABILITY; IMPLEMENTATION FOR PHASE III.

- INTRODUCE DOMSAT TERMINALS AT POCS.
- INTEGRATE CONTROL AND SCHEDULING OF ALL PAYLOAD TRACKING AND DATA ACQUISITION FACILITIES UNDER A SYSTEM NOCC.
- INTRODUCE FULLY COMPATIBLE SYSTEM FOR INTERCENTER DATA TRANSMISSION.
- ESTABLISH SUPERVISORY DATA BASE MANAGEMENT SYSTEM UNDER CENTRAL AUTHORITY.
- IMPOSE STANDARDS FOR DATA FORMATS, COMMAND SYSTEMS AND STRIPPING/PROCESSING DATA FOR STS PAYLOADS.
- INTRODUCE STANDARD OPERATING PROCEDURES FOR
  - REAL TIME MODIFICATION OF FLIGHT PLANS
  - PRIORITY SCHEMES FOR RESOLVING CONFLICTS IN RESOURCES REQUIREMENTS
  - AUTOMATED SCHEDULING SYSTEMS
  - COMPUTERIZED DOCUMENTATION GENERATION AND UPDATE
  - HIGH SPEED, HIGH RESOLUTION FACSIMILE FOR TRANSFER OF HARD COPY BETWEEN REMOTE OPERATORS.
- ESTABLISH OPERATIONAL INTERFACES WITH VAFB.

TASK f

PHASED IMPLEMENTATION APPROACH

Phase III extends from mid 1983 through mid 1986. This is termed the transition phase since it is during this phase that TRW recommends completing transition from a system of unique support facilities for various payload classes to a totally integrated, standardized system where any POCC can support any payload.

Since phase IV requires a full capability to support the maximum number of launches and flight overlaps, implementation of the full systems capability should be completed during phase III to be operational at the start of phase IV.

The facing page lists the system features recommended for implementation during phase III. The major thrust of the activity recommended for this phase is to finalize a standard operational interface with the TUG, phase in the changes necessary to make all POCCs standard and provide a system of portable POCC/DOMSAT Terminals to interface remote users and/or additional centers with the standard NASA-wide network for Payload control.

TASK f

PHASED IMPLEMENTATION APPROACH

PHASE III - 1983 TO 1986 - TRANSITION PHASE - IMPLEMENTATION FOR PHASE IV

- STANDARDIZE OPERATIONAL INTERFACES WITH TUG
- PHASE IN STANDARD OPERATING CONSOLE MODULES AT ALL POCC'S.
- INTRODUCE STANDARD DISPLAY SYSTEMS FOR ALL POCC'S.
- IMPLEMENT STANDARD POCC DESIGNS NECESSARY FOR ANY POCC TO SUPPORT ANY PAYLOAD AND TO PERMIT RECONFIGURATION WITHIN 10 TO 15 DAYS.
- IMPLEMENT STANDARD USER INTERFACES WITHIN HOST FACILITIES FOR USERS TO ACCESS THE INTEGRATED SYSTEM.
- PROVIDE A SYSTEM OF PORTABLE POCC/DOMSAT TERMINALS TO INTERFACE REMOTE CENTERS OR USER FACILITIES WITH HIGH DATA RATE REQUIREMENTS INTO THE NASA SYSTEM. OPERATION OF SUCH A FACILITY WOULD BE UNDER THE DIRECTION OF AN ESTABLISHED POC.

TASK f

PHASED IMPLEMENTATION APPROACH

Phase IV extends from mid 1986 through 1991. The fully integrated NASA-wide STS Payload Support System should be completed by 1986 in order to accommodate the full traffic model for payload launches.

The recommended system will have the advantage of maximum flexibility to respond to changes in payload support requirements during the remainder of the STS operational era. By netting together the NASA resources for computer support, having wide band real time capability for data transfer and capability for quick reconfiguration of POCCs, the system will maximize responsiveness to new or changing requirements.

TASK f

PHASED IMPLEMENTATION APPROACH

PHASE IV - MID 1986 THROUGH 1991 - FULLY INTEGRATED NASA-WIDE STS PAYLOAD SUPPORT SYSTEM.

- SYSTEM SUPPORTS FULL TRAFFIC MODEL.
- ALL SYSTEM ENHANCEMENTS COMPLETE AT BEGINNING OF PHASE IV.
- THE RECOMMENDED INTEGRATED NETWORK OF NASA PAYLOAD CENTERS WILL PROVIDE MAXIMUM FLEXIBILITY FOR RESPONSE TO CHANGES DURING REMAINDER OF STS OPERATIONAL ERA.

TASK f

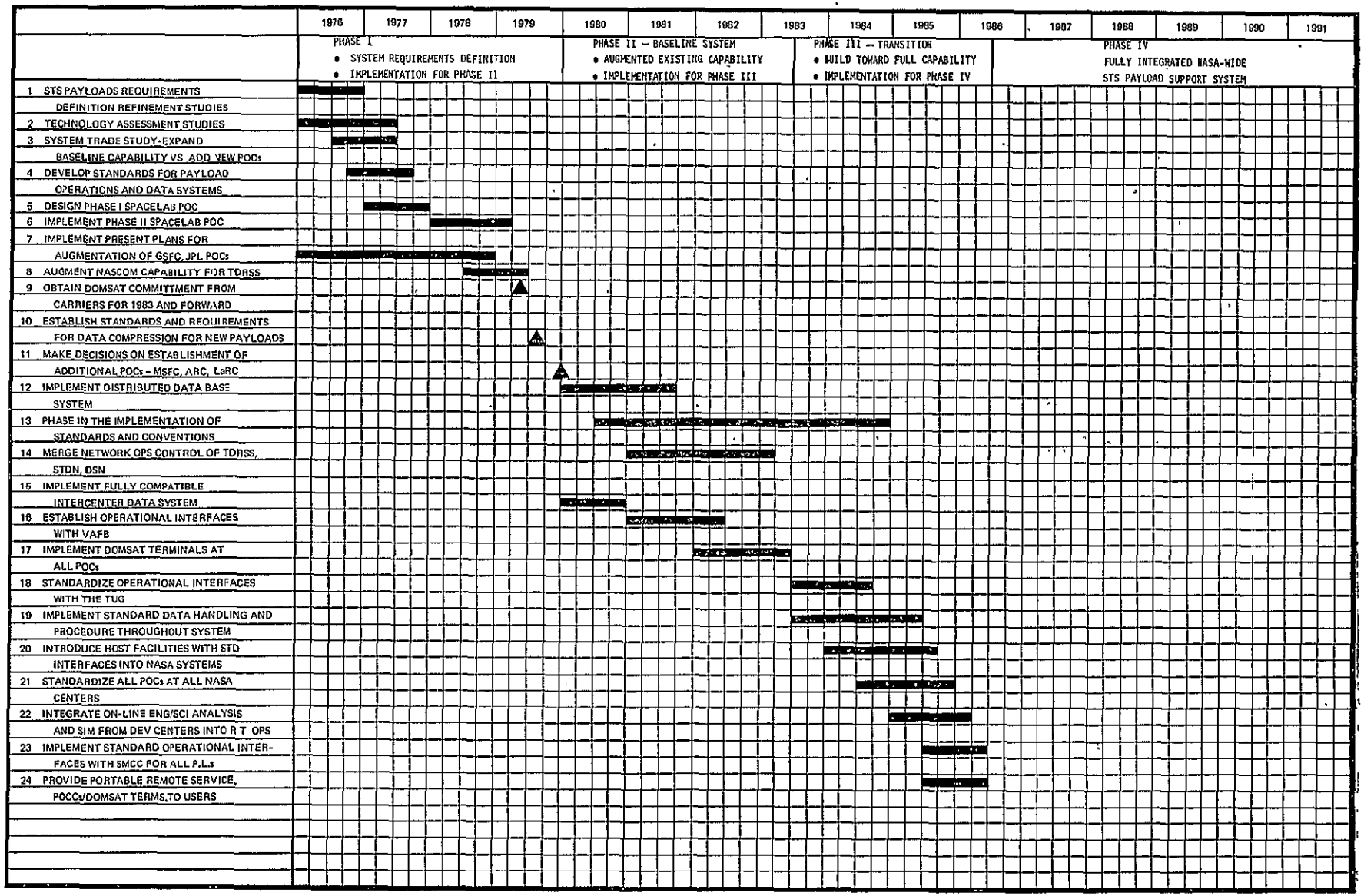
IMPLEMENTATION MILESTONE SCHEDULE

This schedule covers the recommended schedule of implementation activities and program phases, beginning in 1976 and extending through the 1991 time frame. All implementation activities are completed by 1986 which is the beginning of Phase IV. At this time the NASA-wide STS payload support system will begin to experience peak traffic loads resulting from a fully mature Space Transportation System.

The scheduling of system enhancements is designed to produce an evolutionary approach to meeting the increasing requirements of the STS payloads at key points while the requirements build toward the peak load. In addition, the phasing of enhancements provide an evolutionary building block approach which minimizes the impact on the existing system at any point in time.

TASK f

IMPLEMENTATION MILESTONE SCHEDULE



TASK g
RESOURCES MODEL AND ESTIMATING

The objective of this task is to establish a resources estimating methodology and to apply it to estimating non-recurring and recurring resources requirements for the concept chosen in Task f by NASA for STS payloads flight control.

The methodology developed uses standard resources elements and estimating relationships. Types of models that have been evaluated include the "Initial Cost" model, "Life Cycle" model and the "Present Value" model ("Discounted Life Cycle").

Data to be used in Resources estimating for the chosen system concept have been collected throughout the study, principally in Task c.

The resources estimating methodology, model and results for the selected concept will be documented and delivered as Volume II-G of the Final Report.

TASK g
RESOURCES MODEL AND ESTIMATING

OBJECTIVE: DEVELOP/ESTABLISH RESOURCES ESTIMATING METHODOLOGY AND MODEL, AND APPLY TO ESTIMATE RESOURCES FOR NASA-SELECTED CONCEPT.

SUMMARY OF TASK RESULTS:

- ESTABLISHED RESOURCES ESTIMATING METHODOLOGY
- IDENTIFIED APPLICABLE MODELS
- DEVELOPED/IDENTIFIED ELEMENTS FOR USE IN RESOURCES ESTIMATING
- ACTUAL ESTIMATING REMAINS TO BE DONE.
- NON-RECURRING AND RECURRING RESOURCES REPLACEMENT CONSIDERED.

STS PAYLOADS MISSION CONTROL STUDY
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The introduction of a common interface with the STS Operator for all STS payloads establishes the need for an integrated approach to STS payload operations.

A system involving standard POCC's with the capability to support any payload on a quick turn-around basis will provide a higher utilization factor for POCC's and reduce the total number of POCC's required for STS payload support.

If the concept of standard POCC's is adopted it will be necessary to establish early requirements for payload operational standards. This requirement should be phased in gradually over a considerable period of time so as not to impact payload designs presently under way. At the same time, standards should be defined early so as to permit NASA to negotiate them into new payload designs during the formulative stages of the various programs.

A key decision to be made as early as possible is whether to expand the capabilities of the three baseline centers to support all payloads or augment the capability of additional centers to support the increasing load during later phases of the STS payload era.

A major stride in system enhancement for the users will be the introduction of portable POCC/DOMSAT Terminals to provide wideband communications and control capability for remote users or additional centers as an extension of the POCC at one of the baseline centers.

STS PAYLOADS MISSION CONTROL STUDY

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

- AN INTEGRATED, STANDARDIZED, MULTI-CENTER SYSTEM FOR ALL STS PAYLOADS APPEARS TO OFFER THE MOST COST EFFECTIVE APPROACH TO STS PAYLOAD COMMAND AND CONTROL. EXTENSION OF GSFC POCCNET CONCEPT TO ALL CENTERS SHOULD BE INVESTIGATED AS A POTENTIAL APPROACH.
- THE ULTIMATE SYSTEM IS ONE IN WHICH ALL POCC'S ARE STANDARD AND EACH POCC CAN HANDLE ANY PAYLOAD ON A QUICK TURN-A-ROUND BASIS.
- EARLY ESTABLISHMENT OF NASA-WIDE POLICY ON OPERATIONAL AND DESIGN STANDARDS FOR PAYLOADS IS A NECESSARY PREREQUISITE TO ACHIEVING STANDARD GROUND SUPPORT SYSTEMS FOR PAYLOAD FLIGHT OPERATIONS. STANDARDS SHOULD BE IMPOSED ON:
  - COMMUNICATIONS AND DATA FORMATS
  - COMMAND SYSTEMS
  - DISPLAY FORMATS
  - DISTRIBUTED DATA BASES
  - OPERATIONAL PROCEDURES AND INTERFACES
  - REQUIREMENTS FOR DATA COMPRESSION AT THE SOURCE
- A KEY DECISION, NECESSARY EARLY IN THE IMPLEMENTATION CYCLE IS:
  a) SHOULD THE THREE BASELINE POC'S BE EXPANDED TO ACCOMMODATE FULL TRAFFIC MODEL REQUIREMENTS? OR
  b) SHOULD ADDITIONAL CENTERS BE AUGMENTED TO SUPPORT THE INCREASING OPERATIONAL LOAD?
- PROVIDE A STANDARD INTERACTIVE SYSTEM TO IMPLEMENT THE VARIOUS USER INTERFACES WITH PORTABLE DOMSAT TERMINAL FOR WIDE-BAND COMMUNICATIONS TO REMOTE SITES.

STUDY FINAL REPORT

This is the list of 15 documents that constitute the Final Report of this Study. At this time all documents have been completed and distributed by the COR with the exception of Volumes I, II-E, II-F and II-G. Volumes II-E and II-F have been completed and reviewed by the COR. Volumes I and II-G will be completed and distributed by completion of the Study schedule (10th month).

STUDY FINAL REPORT

- VOLUME I - FINAL SUMMARY REPORT
- VOLUME II-A - STUDY TASK a - 1.0 FLIGHT CONTROL FUNCTIONS
- VOLUME II-B - STUDY TASK b - 2.0 TYPES AND LOCATIONS OF PARTIES INVOLVED
- VOLUME II-C - STUDY TASK c - GENERAL, 3.0 INVESTIGATION OF PRESENT/PLANNED NASA-WIDE FACILITIES AVAILABLE
- VOLUME II-C - STUDY TASK c - APPENDIX A - NASA/ARC CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX B - NASA/GSFC CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX C - NASA/JPL CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX D - NASA/JSC CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX E - NASA/KSC CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX F - NASA/LaRC CAPABILITIES
- VOLUME II-C - STUDY TASK c - APPENDIX G - NASA/MSFC CAPABILITIES
- VOLUME II-D - STUDY TASK d - 4.0 ALLOCATION OF FLIGHT CONTROL FUNCTIONS
- VOLUME II-E - STUDY TASK e - 5.0 OPERATIONAL INFORMATION FLOW AND PROCESSING
- VOLUME II-F - STUDY TASK f - 6.0 DEFINITION OF SYSTEM CONCEPTS
- VOLUME II-G - STUDY TASK g - 7.0 RESOURCES MODEL AND ESTIMATES